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ABSTRACT

This superinsulation housing curriculum consists of 14 sections that focus on showing how many household energy problems can be solved through modifications in the methods and materials used to build homes. Section 1 is an overview of low energy housing. The next 13 sections present the content of the curriculum. In addition to narrative informative materials, extensive tables, charts, and figures are provided. All sections, with the exception of section 7, conclude with a bibliography or references (section 9 only). The sections cover Introduction to Superinsulated Construction, Infiltration, Walls, Attic, Foundations, Windows, Entrances, Indoor Air Pollution, Air-to-Air Heat Exchangers, Heating and Cooling Systems, Superinsulation Economics, Marketing Superinsulation, and Consumerism. Appendixes include a Marketing Assistance Package (ideas for publicizing the curriculum), Target Audience Identification, and listing of Superinsulation Curriculum Slides. (YLB)

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MINNESOTA SUPER-INSULATION HOUSING CURRICULUM

Produced By:
Minnesota Departments of
• Education
• Energy, Planning & Development
Hennepin Technical Centers

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FORWARD

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LEE GRESSER - PROJECT COORDINATOR, HENNEPIN TECHNICAL CENTERS
DAVID SMITH - CURRICULUM DESIGNER, HENNEPIN TECHNICAL CENTERS
BILL TeVOGT - CURRICULUM SPECIALIST, HENNEPIN TECHNICAL CENTERS
MICHAEL SCOTT - TECHNICAL CONSULTANT WRITER, SUPERINSULATION LIMITED
TIM POVROZNIK - GRAPHIC DESIGNER/TECHNICIAN
STANTON L. WILLIAMS - ADULT VOCATIONAL PROGRAM SUPERVISOR, MINNESOTA STATE DEPARTMENT OF EDUCATION
BRUCE D. NELSON - SENIOR ENGINEER, MINNESOTA DEPARTMENT OF ENERGY PLANNING AND DEVELOPMENT

TABLE OF CONTENTS

	SECTION	PAGE
I.	Low Energy Housing	I-1
II.	Introduction to Superinsulated Construction	
	A. Robinson Rules-of-Thumb	II-3
	B. Critical Elements	II-5
	C. Superinsulated Retrofit	II-7
	D. Conclusion	II-7-8
	E. Bibliography	II-9
III.	Infiltration	
	A. Vapor Barriers	III-5
	B. Foam Sealants	III-38
	C. Air-to-Air Heat Exchanger	III-38
	D. Bibliography	III-40
IV.	Walls	
	A. Single Wall Strategies: New Construction	IV-2
	B. Double Wall Strategies: New Construction	IV-7
	C. Single Wall Strategies: Retrofit Construction	IV-15
	D. Double Wall Strategies: Retrofit Construction	IV-23
	E. Bibliography	IV-29
V.	Attic	
	A. New Construction	V-3
	B. Retrofit	V-10
	C. Roof Overhang Sizing and Shading	V-14
	D. Bibliography	V-17
VI.	Foundations	
	A. Foundation Walls: New Construction	VI-3
	B. Foundation Walls: Cement Slabs	VI-14
	C. Foundation Walls: Retrofit Construction	VI-14
	D. Foundation Walls: Retrofit	VI-16
	E. Bibliography	VI-19
VII.	Windows	
	A. Window Criteria	VII-3
	B. Bibliography	VII-8
	C. Window Treatments	VII-9
VIII.	Entrances	
	A. Doors	VIII-1
	B. Air Locks	VIII-1
	C. Bibliography	VIII-4

TABLE OF CONTENTS

SECTION		PAGE
IX.	Indoor Air Pollution	
	A. Classes of Pollutants	IX-2
	B. Impact of Energy Efficient/Solar Design on....	IX-2
	C. Health effects of Elevated Indoor Generated Pollutants	IX-5
	D. Control Strategies	IX-7
	E. Conclusion	IX-10
	F. References	IX-13
X.	Air-to-Air Heat Exchangers	
	A. Air-to-Air Heat Exchanger Description	X-2
	B. Air-to-Air Heat Exchanger Features	X-3
	C. Air-to-Air Heat Exchanger Installation	X-5
	D. Air-to-Air Heat Exchanger Economics	X-6
	E. Bibliography	X-9
XI.	Heating and Cooling Systems	
	A. Heating and Cooling System Sizing	XI-3
	B. Heating System Selection	XI-4
	C. Electric Heating System	XI-4
	D. Natural Gas Heating Systems	XI-5
	E. Wood Heat	XI-6
	F. Cooling System Selection	XI-7
	G. Bibliography	XI-8
XII.	Superinsulation Economics	
	A. Simplified Economic Analysis	XII-2
	B. Detailed Economic Analysis	XII-10
	C. Life-Cycle Costing Advantages	XII-12
	D. Pay-back	XII-13
	E. Return on Investment	XII-14
	F. Life-Cycle Costing Methodology	XII-14
	G. Years-to-Positive Cash Flow	XII-22
	H. Can Retire Loan	XII-22
	I. Value of Installed KW Capacity not needed	XII-24
	J. Cost of Energy not Consumed	XII-24
	K. Superinsulation's Annual Effectiveness	XII-26
	L. Bibliography	XII-30

TABLE OF CONTENTS

SECTION		PAGE
XIII.	Marketing Superinsulation	
	A. Marketing Philosophy	XIII-3
	B. Superinsulation Benefits	XIII-5
	C. Bibliography	XIII-8
XIV.	Consumerism	
	A. Consumer Questions and Answers	XIV-2
	B. Bibliography	XIV-9

APPENDIX A:
Marketing Assistarce Package

APPENDIX B:
Target Market Identification

APPENDIX C:
Superinsulation Curriculum Slides

TABLE OF CONTENTS

TABLES

TABLE I-1	HOUSEHOLD ENERGY CONSUMPTION
TABLE V-1	OVERHANG SIZING AT 45° N. LATTITUDE
TABLE IX-1	INDOOR POLLUTANT CHARACTERISTICS, IMPACTS AND CONTROLS
TABLE X-1	AIR-TO-AIR HEAT EXCHANGER PAYBACK
TABLE XI-1	HEATING/COOLING COMPARISON
TABLE XII-1	SUPERINSULATED HOUSE BUILDING CHARACTERISTICS AND COST
TABLE XII-2	SIMPLIFIED ENERGY LIFE-CYCLE COMPARISON
TABLE XII-3	CUMULATIVE OUT-OF-POCKET LIFE-CYCLE COSTS
TABLE XII-4	LIFE-CYCLE ASSUMPTIONS
TABLE XII-5	LIFE-CYCLE ASSUMPTIONS, PART 2
TABLE XII-6	LIFE-CYCLE COST ANALYSIS
TABLE XII-7	LIFE-CYCLE COST ANALYSIS
TABLE XII-8	SUPERINSULATION'S EFFECTIVENESS TO REDUCE COOLING REQUIREMENTS
TABLE XII-9	SUPERINSULATION'S ANNUAL EFFECTIVENESS

FIGURES

FIGURE III-1 AREAS OF INFILTRATION

FIGURE III-2

FIGURE III-3 VAPOR BARRIER AT INTERIOR WALL AND TRUSS

FIGURE III-4 VAPOR BARRIER FOR PARTITION WALL AND SINGLE TOP PLATE

FIGURE III-5 INTERIOR PARTITION VAPOR BARRIER WITH SINGLE TOP PLATE

FIGURE III-6 VAPOR BARRIER AT INTERIOR AND EXTERIOR WALLS

FIGURE III-7 VAPOR BARRIER AT INTERIOR AND EXTERIOR WALLS

FIGURE III-8 VAPOR BARRIER AT WALL AND TRUSS

FIGURE III-9 VAPOR BARRIER AT WALL AND FLOOR

FIGURE III-10 VAPOR BARRIER AT INTERIOR WALL AND TRUSS

FIGURE III-11 VAPOR BARRIER CONTINUITY MAINTENANCE

FIGURE III-12 INTERIOR CEILING VAPOR BARRIER WITH DOUBLE BLOCKING

FIGURE III-13 VAPOR BARRIER INSTALLATION AT WALL AND CEILING FOR INTERIOR PARTITION

FIGURE III-14 VAPOR BARRIER INSTALLATION FOR INTERIOR PARTITION OVER CRAWL SPACE

FIGURE III-15 VAPOR BARRIER INSTALLATION FOR INTERIOR PARTITION OVER CRAWL SPACE

FIGURE III-16 VAPOR BARRIER INSTALLATION AT PARTITION WALL AND CEILING

FIGURE III-17 VAPOR BARRIER AT WALL AND VAULTED CEILING

FIGURE III-18 VAPOR BARRIER AT SPLIT LEVEL CEILING CORNERS

FIGURE III-19 VAPOR BARRIER AT SPLIT LEVEL CEILING CORNERS

FIGURE III-20 VAPOR BARRIER AT SPLIT LEVEL CORNERS

FIGURE III-21 BASEMENT INTERIOR STUD WALL VAPOR BARRIER INSTALLATION

FIGURE III-22 VAPOR BARRIER AND SEALANT AT WINDOWS AND DOORS

FIGURE III-23 WINDOW DETAIL - CANADIAN DOUBLE WALL

FIGURE III-24 WINDOW VAPOR BARRIER DETAIL FOR DOUBLE WALL CONSTRUCTION

FIGURE III-25 SEALING THE VENT PIPE

FIGURE III-26 VAPOR BARRIER INSTALLATION AROUND PLUMBING VENT STACK

FIGURE III-27 PLUMBING VENT STACK DETAIL

FIGURES (CONTINUED)

FIGURE III-28 VENT WALL DETAIL
FIGURE III-29 SERVICE ENTRANCE
FIGURE III-30 CHIMNEY INSTALLATION DETAIL
FIGURE III-31 SEALING VAPOR BARRIER PENETRATION VENT PIPES, ETC.
FIGURE III-32 VAPOR BARRIER/ELEC. BOX

FIGURE IV-1 2 x 6 WALL FRAMING
FIGURE IV-2 2 x 8 WALL FRAMING
FIGURE IV-3 ALASKANDINAVIAN WALL
FIGURE IV-4 VAPOR BARRIER TREATMENT AT HEADER
FIGURE IV-5 RIM JOIST DETAIL
FIGURE IV-6 DOUBLE 2 x 4 WALL FRAMING
FIGURE IV-7 VAPOR BARRIER AT WALL AND FLOOR
FIGURE IV-8 CANADIAN WALL WITH WOOD FOUNDATION
FIGURE IV-9 CANADIAN DOUBLE WALL
FIGURE IV-10 CANADIAN WALL DETAIL
FIGURE IV-11 DOUBLE WALL WITH WOOD FOUNDATION
FIGURE IV-12 RETROFIT
FIGURE IV-13 RETROFIT VAPOR BARRIER AT INTERIOR AND EXTERIOR WALLS
FIGURE IV-14 RETROFIT OF VAPOR BARRIER AT JOISTS
FIGURE IV-15 CURTAIN WALL ATTACHMENT
FIGURE IV-16 RETROFIT OF EXTERIOR WALLS
FIGURE IV-17 WINDOW CASING DETAIL

FIGURE V-1 ATTIC VAPOR BARRIER AT INSULATION DETAIL
FIGURE V-2 ATTIC
FIGURE V-3 SOFFIT DETAIL
FIGURE V-4 CATHEDRAL CEILING
FIGURE V-5 CATHEDRAL
FIGURE V-6 OVERHANG SIZING FOR WINTER AND SUMMER
FIGURE V-7 INTERIOR ATTIC HATCH DETAIL
FIGURE V-8 INTERIOR ATTIC HATCH DETAIL

FIGURE VI-1 SPLIT LEVEL DOUBLE WALL CONSTRUCTION
FIGURE VI-2 BASEMENT WALL AND FLOOR
FIGURE VI-3 VAPOR BARRIER AT WALL AND CONCRETE FLOOR
FIGURE VI-4 VAPOR BARRIER TREATMENT AT RIM JOISTS
FIGURE VI-5 CRAWL SPACE FOUNDATION
FIGURE VI-6 SLAB ON GRADE FOUNDATION
FIGURE VI-7 WOOD FOUNDATION WITH FLOOR TRUSS
FIGURE VI-8 CONCRETE FOOTING DETAIL FOR WOOD FOUNDATION WALL
FIGURE VI-9 RETROFIT BASEMENT WALL WITH DOUBLE CROSSHATCHING FLOOR

FIGURE VII-1 OVERHANG SIZING FOR WINDOW PLACEMENT
FIGURE VII-2 TECHNIQUE TO AVOID WINDOW CONDENSATION

FIGURE VIII-1 AIR-LOCK ENTRIES

FIGURE XI-10 RETROFIT BASEMENT WALL AND FLOOR

CHARTS

CHART I-1	WINTER HEATING REQUIREMENTS
CHART I-7	MINNESOTA HOUSEHOLD ENERGY CONSUMPTION
CHART XII-1	SIMPLIFIED OUT-OF-POCKET LIFE-CYCLE ENERGY COSTS

I. LOW ENERGY HOUSING

--INTRODUCTION--

The Low Energy Home is designed to reduce energy consumption in three basic areas:

(1) space conditioning (e.e., either heating or cooling)

(2) hot water; and

(3) appliances and lighting

"You simply cannot have a low energy house unless you have low energy people." The homeowner, to save energy and save money, must be cognizant and dedicated to conserving energy before any truly successful energy saving investments can be effective.

The objective is to emphasize those investments in building materials and components that are designed to save energy dollars. To better understand the need and the potential to reduce household energy consumption, three fundamental questions must be asked and answered.

(1) Where and how is energy consumed in the home?

(2) What strategies can be used to save energy?

(3) How much energy can be saved by fully implementing these strategies?

Answers to these questions can be seen by reviewing the typical areas of household energy consumption. Table I-1 highlights the basic energy consuming areas of a typical conventional 2,000 square foot Minnesota house, built to the current building standards, compared to that of a

TABLE I - 1

HOUSEHOLDS ENERGY CONSUMPTION

(Andover, Minnesota)

	PRE-1975 SPECS Annual Kwh	LOW ENERGY SPECS Annual Kwh	% Savings
1. Auxiliary Heating (furnace)	28,191	4,470	84
2. Air Conditioning	3,835	1,547	60
3. Water Heating	4,811	1,668	65
4. Refrigerator/Freezer	1,665	564	66
5. Freezer	1,312	—	100
6. Clothes Dryers	1,032	500	52
7. Kitchen Oven/Range	782	500	36
8. Lighting	712	500	30
9. Other Appliances	1,500	1,000	33
Dishwasher	149		
Clothes Washers	88		
Humidifiers/Dehumidifiers	269		
Kitchen	270		
Living Room	82		
Bedroom	48		
Bathroom	57		
Shop and Hobby	267		
Miscellaneous	270		
	43,846	10,749	

house built to Low Energy specifications.

Assuming no change in life-style, the owner of the same house built to superinsulation specifications (row 1 & 2) can reduce annual heating and cooling costs by over 80%. Incorporating changes in appliance energy efficiency and life-style, hot water energy requirements can be reduced by two-thirds and energy requirements for most household appliances can be reduced by at least one-third.

Energy saving investments for more energy efficient components are not the only means of reducing winter heating bills. For example, Chart I-1, shows how winter fuel bills can be effected by simply setting the thermostat back 5°F. Each degree (F°) the thermostat is set back saves 40 to 50 gallons of fuel oil. Again, much of what can be saved does not depend on dollar investments for fancy energy gadgets. Instead, the homeowners desire to save is the single most important component.

The homeowner has direct control over the selection of many energy consuming areas. For example, the efficient use and selection of energy efficient appliances and lighting can provide substantial reductions in home energy consumption. The refrigerator, freezer, clothes dryer, kitchen range and lighting consume nearly 60% of the energy needed to operate the home (excluding space conditioning and hot water).

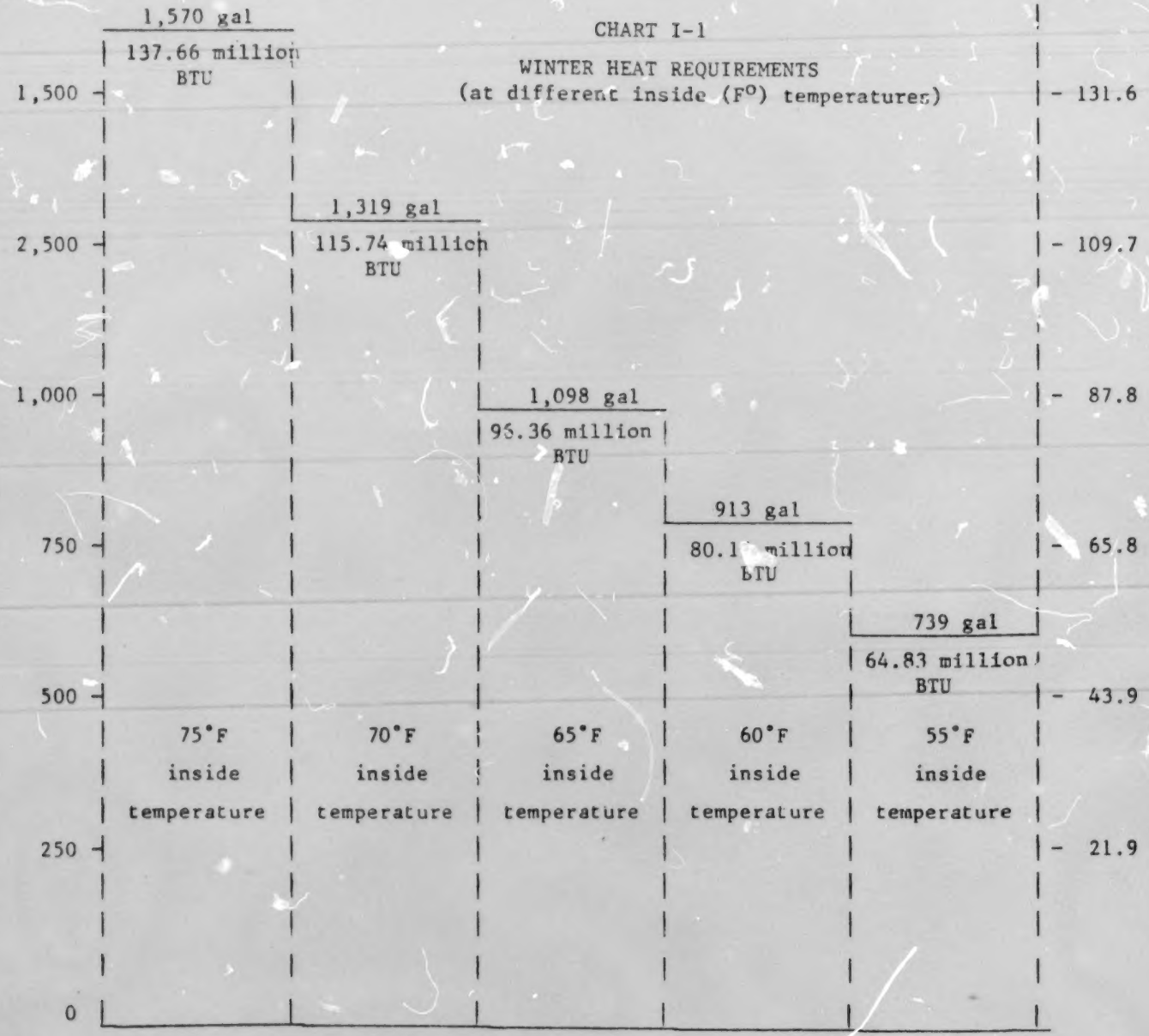
Improving appliance efficiency can save a lot of energy; for example,

Gallons of Fuel Oil

Millions (10^6) BTU Electric Heat

CHART I-1

WINTER HEAT REQUIREMENTS
(at different inside (F^o) temperatures)



REFRIGERATORS

The Amana 11 cu. ft. Es14 - 564 kwh/yr

The Admiral 12.7 cu. ft. CNS895 - 3,144 kwh/yr

or

FREEZERS

The Amana 10 cu. ft. C10B - 828 kwh/yr

The K-Mart 10.7 cu. ft. V10 - 1,572 kwh/yr

The curriculum objective is to show how many household energy problems can be solved through modifications in the methods and materials used to build homes. However, it is even more important to realize the solution to many energy problems is simply to modify our lifestyles or our energy habits.

To live in a low energy home requires modifications to ensure (1) the structure is sealed and insulated; (2) hot water is used and produced efficiently; (3) appliances selection and use is efficient and energy habits are good. For a low energy home to work:

(1) Keep the average house temperature low in winter and up in summer.

(2) Reduce the space conditioning for unoccupied rooms.

(3) Use night set-back of temperature.

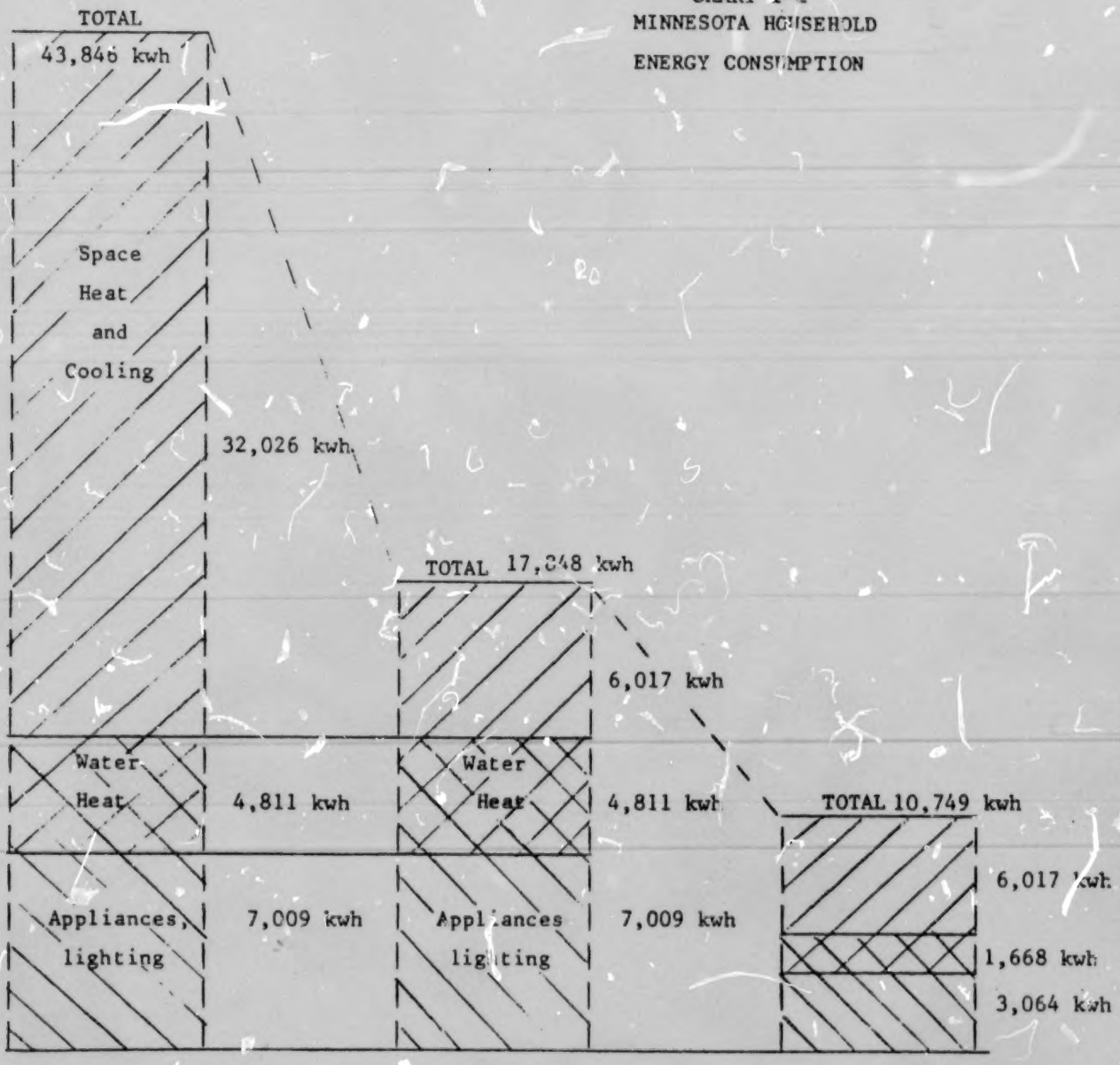
(4) Install energy efficient appliances and water heaters.

Chart I-2 illustrates how household energy consumption can be influenced by several energy conservation strategies. Total energy consumption for

typical Minnesota family of four, living in a 2,000 ft^2 home, is shown in column one.

The second column shows the energy impact of superinsulation alone. The third column shows the combined energy impact of superinsulation coupled with low energy strategies for domestic hot water and appliances.

CHART I-2
MINNESOTA HOUSEHOLD
ENERGY CONSUMPTION



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II. INTRODUCTION TO SUPERINSULATED CONSTRUCTION

TABLE OF CONTENTS

	PAGE
A. ROBINSON RULES-OF-THUMB	3
B. CRITICAL ELEMENTS	5
C. SUPERINSULATED RETROFIT	7
D. CONCLUSION	7-8
E. BIBLIOGRAPHY	9

SUPER INSULATION MEANS:

SIMPLEST
THINGS
FIRST

SUPER INSULATION MEANS:

- Flexibility

SUPER INSULATION MEANS:

- Paying attention to detail
- Using common sense

II-1a

SUPER-INSULATION MEANS:

- Save Energy
- Save Dollars
- Create Profits

SUPER-INSULATION MEANS:

- Wall R values of 30 or more
- Ceiling R values of 50 or more
- Basement wall R values of 20 or more
- Windows triple glazed
- and more...

SUPER-INSULATION MEANS:

- Air infiltration rate of ¼ or less
- Effective air infiltration barriers
- Air-to-air heat exchangers

--INTRODUCTION--

Much of the oil, natural gas, and electricity which is used to heat and cool our homes is wasted. Certain types of passive solar homes have been indentified as good economic values. The super insulated home is a special type of energy efficient passive solar construction. A construction strategy that seeks not to maximize solar gain, but to minimize energy and mortgage payments.

In the Northern Great Plains, the extra features incorporated into new superinsulated houses has reduced annual heating bills by 80% to 90%, or more, while costing $3,000 to $5,000 more than conventional house constuction. This is the key to superinsulation, while annual mortgage payments are increased $300 to $500, fuel bills are reduced $500 to $900 or more. The homeowner is typically dollars ahead after the first or second winter. The basic concept in designing and building a superinsulated house is KIS (keep it simple). That is, doing the simplist-things-first.

The most energy/cost effective house can be built by (1) controlling infiltration, (2) heavily insulating, and (3) using modest direct solar gain.

In addition to new construction, superinsulation retrofit techniques have recently been applied to houses undergoing major renovation.

The curriculum reflects the experience gained from the building and

living in new superinsulated houses in Minnesota, the Dakotas, Nebraska, Wisconsin, Illinois, Michigan, Saskatchewan and Alaska. The techniques and materials suggested are commonly used in climates having more than 6,000 degree days (DD) to reduce winter heating costs. However, the basic concepts are also suitable and are now being evaluated and applied in milder climates where superinsulation can reduce summer air conditioning costs.

The objective is to demonstrate that superinsulation is a means to:

SAVE ENERGY.....

SAVE DOLLARS.....

CREATE PROFITS ! ! ! ! !

SUPERINSULATION combines a few new ideas with existing building techniques and components. The revolutionary result is a home that may not need a furnace! The other major discovery is that superinsulation means flexibility for the designer, the builder, the banker, the utility, and the homeowner.

The application of superinsulated building techniques and components is recognized as an attractive alternative for the home building industry. However, a clear definition of what superinsulation means has not yet been developed.

A number of superinsulation definitions have been proposed, William

Shurcliff[1] defines the superinsulated home:

"I use this term to mean a house that is situated in a cold climate (4000 degree days or colder) and: receives only a modest amount of solar energy (for example, has a south-facing window area not exceeding 8 percent of the floor area), is so well insulated and is so airtight that, throughout most of the winter, it is kept warm soley by (a) the modest amount of solar energy received through the windows and (b) miscellaneous within-house heat sources (intrinsic heat sources). Little auxiliary heat is needed: say less than 15 percent as much as is required by a typical house that was built before 1974 and is in comparable size."

The working definition for superinsulation of those in the cold prairie climates of the U.S. and Canada has evolved around basic Rules-of-Thumb developed by David A. Robinson during the winter of 1976-77.

---

1. William A. Shurcliff, Superinsulated Houses and Double Envelope Houses, Brick House Publishing Company, Andover, Mass. 1981.

A. ROBINSON RULES-OF-THUMB

Briefly, the "Robinson Rules-of-Thumb" applied to new construction serve as a guide toward finding the optimum levels of insulating a house by balancing the 30 year mortgage cost to insulate the structure (cost of materials, labor, money, inflation, tax credits, etc.) versus the 30 year cost for energy.[2]

The Robinson Rules-of-Thumb serves as a guide to identify the proper balance for investment in R-value for each building component (windows, attic, walls, etc.). Each row represents an energy/economic balance for each building component. In applying the "Robinson Rules-of-Thumb"below, the best investment in affordable energy efficient house construction occurs in the lower two rows.

---

2. David A. Robinson, "Life-Cycle Cost Economic Optimization of Insulation, Infiltration and Solar Aperture in Energy Efficient Houses". (Spring 1981)

ROBINSON RULES-OF-THUMB

SURFACE	WINDOWS	OPEN ATTIC (cellulose)	FRAME WALLS (fiberglass)	BASEMENT WALL	BASEMENT FLOOR
R	1	18	11	8	4
VALUES	2	37	21	16	7
	3	55	32	24	11
	4	73	42	33	15

Houses with triple-glazed windows; R-55 in the attic; R-32 above grade walls; R-24 below grade walls and R-11 below the basement slab floor would have an annual heating bill below $200. A house having a quadruple glazed (4 layers of glass) windows, R-73 attic, R-42 above grade walls, R-33 below grade and R-15 below the basement slab floor would have an annual heating bill below $100. These rules emphasize the need to balance energy saving technologies. For example, the use of R-73 attic insulation is wasteful if the windows are single glazed. Also, R-42 in the walls is not cost effective if the attic has R-18 insulation.

B. CRITICAL ELEMENTS

These rules were derived using actual builder experiences and cost data applied to cold climate construction. Superinsulation in this environment has evolved to mean incorporating a few new ideas with existing building techniques and components. The revolutionary results are homes in very cold climates that do not need a furnace.

The critical elements are simply paying attention to detail and using common sense. Specifically, superinsulated homes:

1. Have very effective infiltration barriers used to reduce infiltration to ½ air change per hour (ACH) or less. Since the (ACH) is low, superinsulated homes have a new component -- an air-to-air heat exchanger.

2. Are heavily insulated.

-Wall R values of 30 or more
-Attic R values of 50 or more
-Basement wall R values of 20 or more
-Windows triple glazed or more

3. Re-orient window area to utilize direct solar gain in cost effective manner.

-Glass area is equal to approximately 12% of floor area
-70% of glass area faces South
-30% of glass area faces non South

C. SUPERINSULATED RETROFIT

Superinsulated concepts incorporated into extensive renovations of existing houses have produced dramatic energy savings. To be cost-effective, however, the superinsulated retrofits involve much more than blowing more insulation in the attic; or sealing infiltration cracks; or weatherstripping; or replacing or upgrading doors and windows; or altering furnaces and ventilation systems. A superinsulated retrofit involves the construction of new walls, and even new attics or foundations.

At present, not enough is understood about the methods and costs required for the superinsulated retrofit. No rules-of-thumb determining the optimal levels balancing mortgage costs and insulating costs exist for the superinsulated retrofit. Each retrofit is unique. Thus, each must be separately analyzed to determine the most cost-effective retrofit strategy and mix for insulation of the walls, attic, basement, etc.

D. CONCLUSION

Finally, it is important to remember superinsulated design is very forgiving. Variations from these basic guidelines only slightly influence performance if common sense is used. For example, window orientation can be 20^0 degrees from due south without effecting solar gain.

Another simpler definition for the consumer states a superinsulated

home requires no more than four (4) toasters to heat the house during the coldest winter night. Some existing superinsulated homes in Minnesota and Canada use 3,000 watts (2½ toasters) or less for auxiliary heating (i.e., the furnace).

The small size of the auxiliary heating (and cooling) system is another major difference between superinsulated and conventional home construction. Conventional homes maintain comfortable temperatures primarily by relying on a large mechanical plant for heating in winter and cooling in summer. The superinsulated home relies primarily on an air tight vapor barrier and a heavily insulated building envelope to maintain comfort.

Superinsulation is becoming an increasingly popular building trend for new construction. Superinsulated homes can reduce winter heating costs by 80%+, while also reducing summer cooling costs by 60%+. Growing consumer demand, and builder interest is making superinsulation an increasingly popular building trend.

E. BIBLIOGRAPHY

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III INFILTRATION

TABLE OF CONTENTS

	PAGE
A. VAPOR BARRIERS	5
B. FOAM SEALANTS	38
C. AIR-TO-AIR HEAT EXCHANGER	38
D. BIBLIOGRAPHY	40

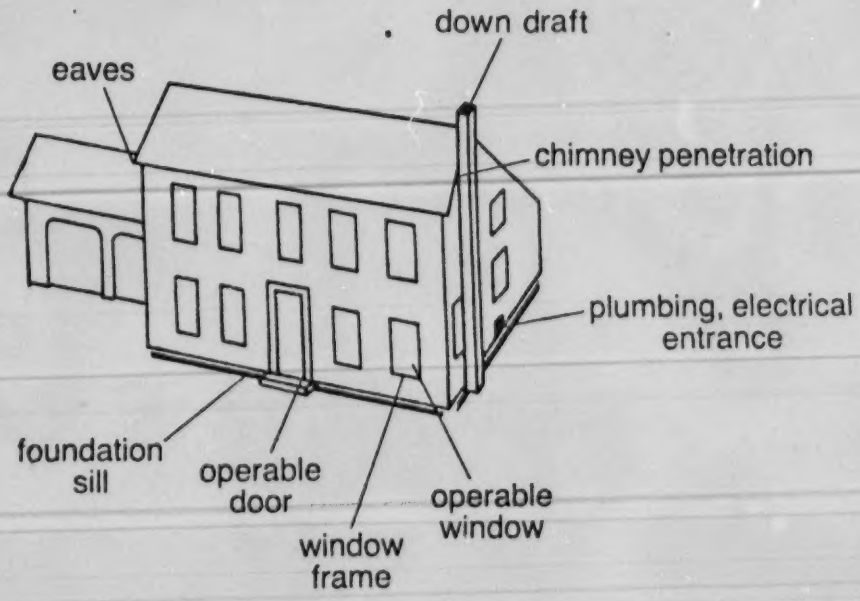
--INTRODUCTION--

Reducing infiltration is the easiest, most cost effective means to save energy and dollars. A superinsulated house is very tightly sealed. Conditioned indoor air is simply not allowed to leak from the structure. The typical infiltrated paths shown and listed in Figure III-1, are typically the size of a 2 or 3 square foot window left open year around, that can increase heating bills by 50%. These drafts also make the house much more uncomfortable.

The importance of proper infiltration reduction strategies cannot be overemphasized. While dramatically reducing heat loss from infiltrating outside air, moist warm interior air is also prevented from condensing inside the insulated wall cavity. This effectively prevents the creation of a moisture condensing environment favorable for wood decay (e.g., dry rot) and reduced insulation R-values.

AREAS OF INFILTRATION

Operable	Building Interface	Penetration
Doors	Corners	Plumbing Entrance
Windows	Window Frames	Exterior faucets
	Door Frames	Plumbing Vent Stack
	Porch Connections	Electrical Entrance
	Eaves	Recessed Lighting
	Sills	Electrical Outlets
	Foundation	Chimney Penetration
	Baseboards	Dryer Vent
		Bathroom Vent
		Kitchen Vent
		Telephone Wire Ent.
		Air Conditioner



AREAS OF INFILTRATION

SUPERINSULATION LTD.

FIGURE III - 1

Three infiltration control strategies are used to build a superinsulated house:

-Vapor Barriers

-Foam Sealants

-Air-to-Air Heat Exchangers

Superinsulated, supertight construction requires different techniques, greater emphasis on quality and more design planning. Builders of superinsulated homes did not acquire these skills easily. Instead, current vapor barrier material selection and installation techniques shown now and later have evolved almost on a trial and error basis. This experience has taught how vapor barrier installation can be effectively streamlined.

Since the mid-1970's, the superinsulated approach for vapor barrier installation has been continuously changing and improving.

Initially, the vapor barrier was patched, pieced, and/or foamed in place as best as possible after the framing was completed. The vapor barrier was regarded as important, but only installed just before the drywall.

By 1980, vapor barrier installation was being planned at the blueprint stage. The blueprints were identifying proper vapor barrier installation especially around windows, doors, utility runs, foundations, etc. Yet,

there remained significant amounts of patching and piecing and foaming. Even though vapor barrier installation was planned, problems were still occuring in areas like rim joists, because the basic house framing remained unchanged.

In 1982, the house design strategy requires slight modification in the construction and framing methods to make vapor barrier installation easier and more continuous. By integrating the vapor barrier into the entire construction process many of the prior vapor barrier problems requiring extensive patching and/or foaming are being eliminated.

A. VAPOR BARRIERS

The vapor barrier is particularly important to a superinsulated house. Experience gained from previous superinsulated homes has revealed the traditional vapor barrier concept must be changed. The vapor barrier is not only essential to prevent moisture from seeping into the walls where is might cause dry rot, it also keeps the warm inside air where it belongs: Inside the House. There appears no great technical advantage for using one thickness of polyethylene vapor barrier over another. However, the best practical choice is 6-mil, because it resists accidental punctures and tears.

The installation of the vapor barrier should be planned before construction begins. All vapor barrier details should be carefully documented on the builder blueprints. Two booklets from Saskatchewan Air-Vapour Barriers and Energy Efficient Housing: A Prairie Approach provide excellent resource materials illustrating common vapor barrier details, especially in difficult areas (common walls on split level houses, elevation changes, cantilevered floor joists, fireplaces, utility rooms, rim joists, window and door installation).

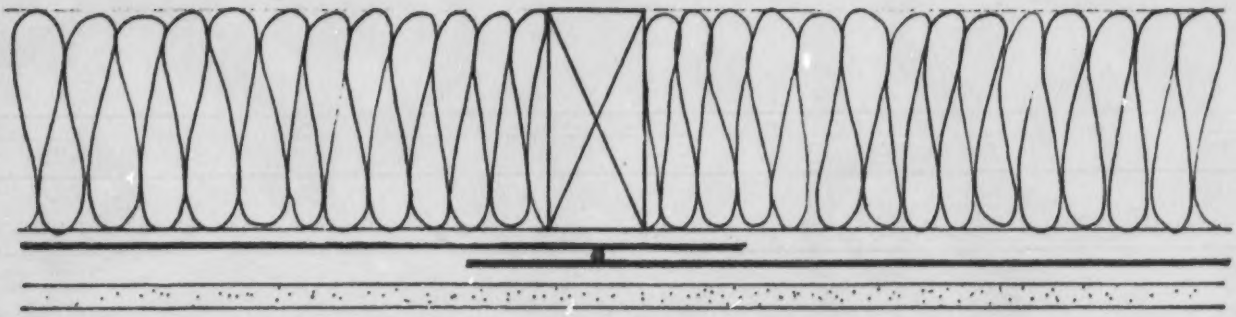
The basic strategy is the preparation of a continuous vapor barrier surface having no gaps or penetrations. To accomplish this goal, a 6-mil polyethelene sheet is applied to form a tight, continuous vapor barrier covering the warm (interior) side of the insulation. All seams must be overlapped. If the overlap is only several inches, a silicone type sealant or adhesive must be used to ensure an air-tight seal to supplement the stapling.

Another method to ensure the air-tight seal is to tightly overlap the vapor barrier from stud to stud and to tightly staple. (see Figure III-2)

Planned or unplanned penetrations of the vapor barrier must be effectively patched and sealed. For example, one way to avoid penetrating the wall vapor barrier for wall outlets is mount them in the floor. Wall lamps and swag fixures are good alternatives to ceiling fixtures. Later sections will illustrate alternative construction strategies designed to avoid vapor barrier penetrations. However, some planned and unplanned accidental vapor barrier tears will occur. These can be effectively patched and sealed with an industrial grade transparent polyethylene tape.

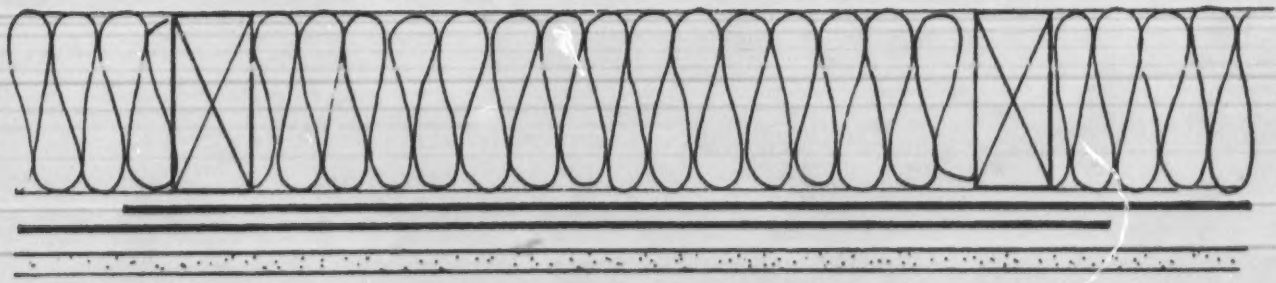
Vapor barrier installation requires eight steps.

1. Protect vapor barrier integrity during all construction stages (especially during drywalling or utility run installation).
2. Join vapor barrier sheets over a solid backing (e.g., stud, joist, plate, etc.).
3. Apply a continuous bead of acoustical or silicone type sealant before stapling. Overlap between vapor barriers (remember to flatten the bead of caulk).
4. Integrate preparatory vapor barrier installation into all framing work.



RECOMMENDED JOINT

TWO INCH OVERLAP OVER FRAMING (INCLUDES CONTINUOUS BEAD OF ACCOUSTICAL SEALANT AT STAPLED SEAMS)



MAXIMUM JOINT

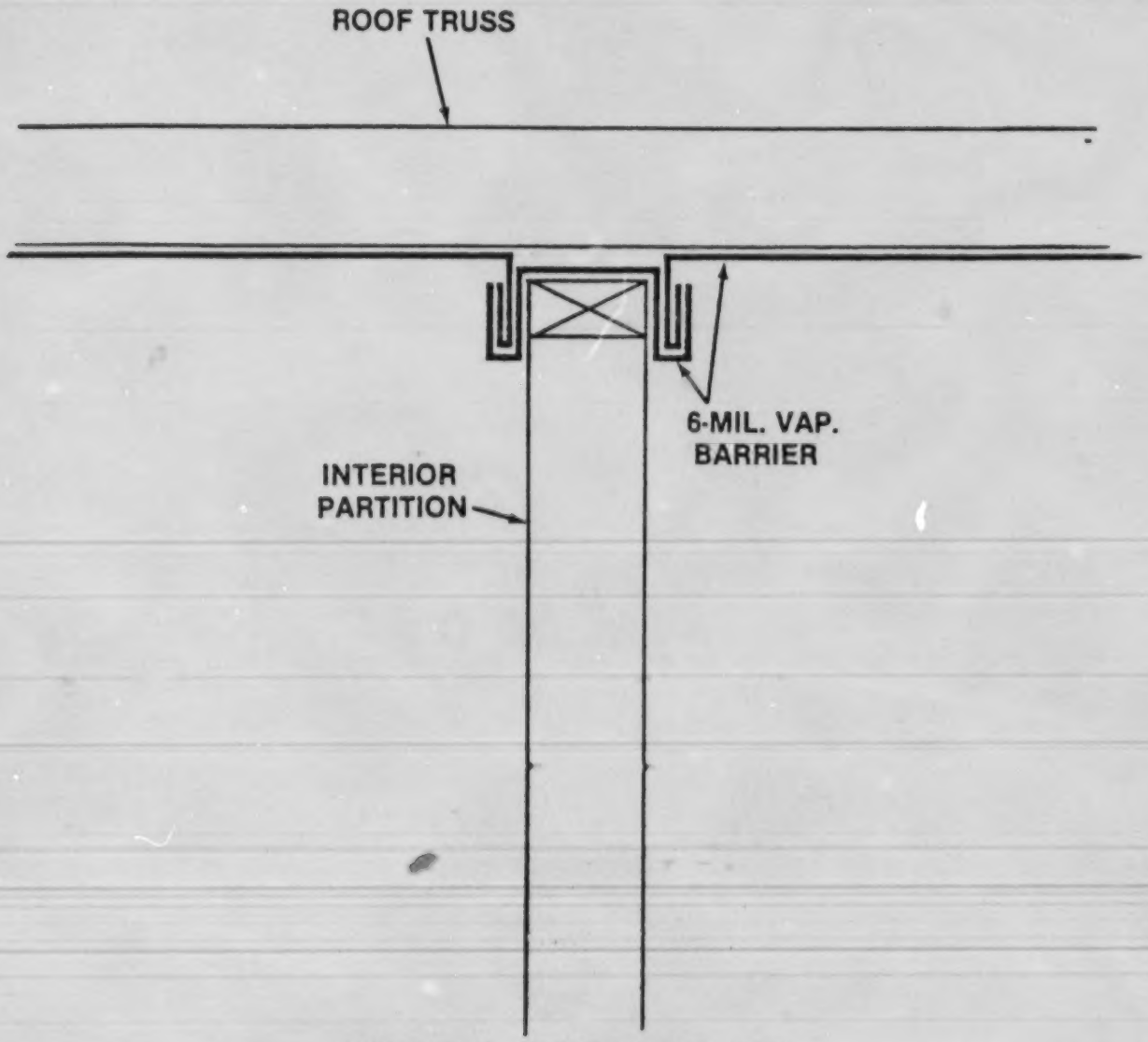
OVERLAP ONE FRAMING SPACE

FIGURE III - 2

(Figures III-3 through III-21) Or ideally re-arrange interior partition framing to be erected after ceiling vapor barrier and drywall are attached.

5. Seal vapor barrier around doors and windows before installation. (Figures III-22 through III-24).
6. Seal vapor barrier around utility runs (e.g., outlets, pipes, vents, and chimneys). (Figures III-25 through III-32).
7. Place vapor barrier under slab floor (especially around floor drain) to block air leakage and prevent moisture wicking from subsurface soils.
8. Remove excess vapor barrier at interior or exterior corners, sealing all edges with non-hardening sealants, foams or tape to minimize potential creation of air pockets.

Integrity of the vapor barrier for walls, ceilings, windows, floors, foundations, etc. is a recurrent theme to be followed throughout construction. This even requires vapor barriers below concrete slabs or crawl spaces to block the earth's moisture from entering (or wicking) into the living area and/or walls. The added cost (labor and materials) of more and thicker vapor barriers is typically $200 to $300. An investment that has less than a one year payback.



VAPOR BARRIER AT INTERIOR WALL AND TRUSS

FIGURE III - 3

If the vapor barrier is applied after placement of the partition walls, a 16-inch wide piece of vapor barrier should be fastened over the top plate of interior walls before placement.

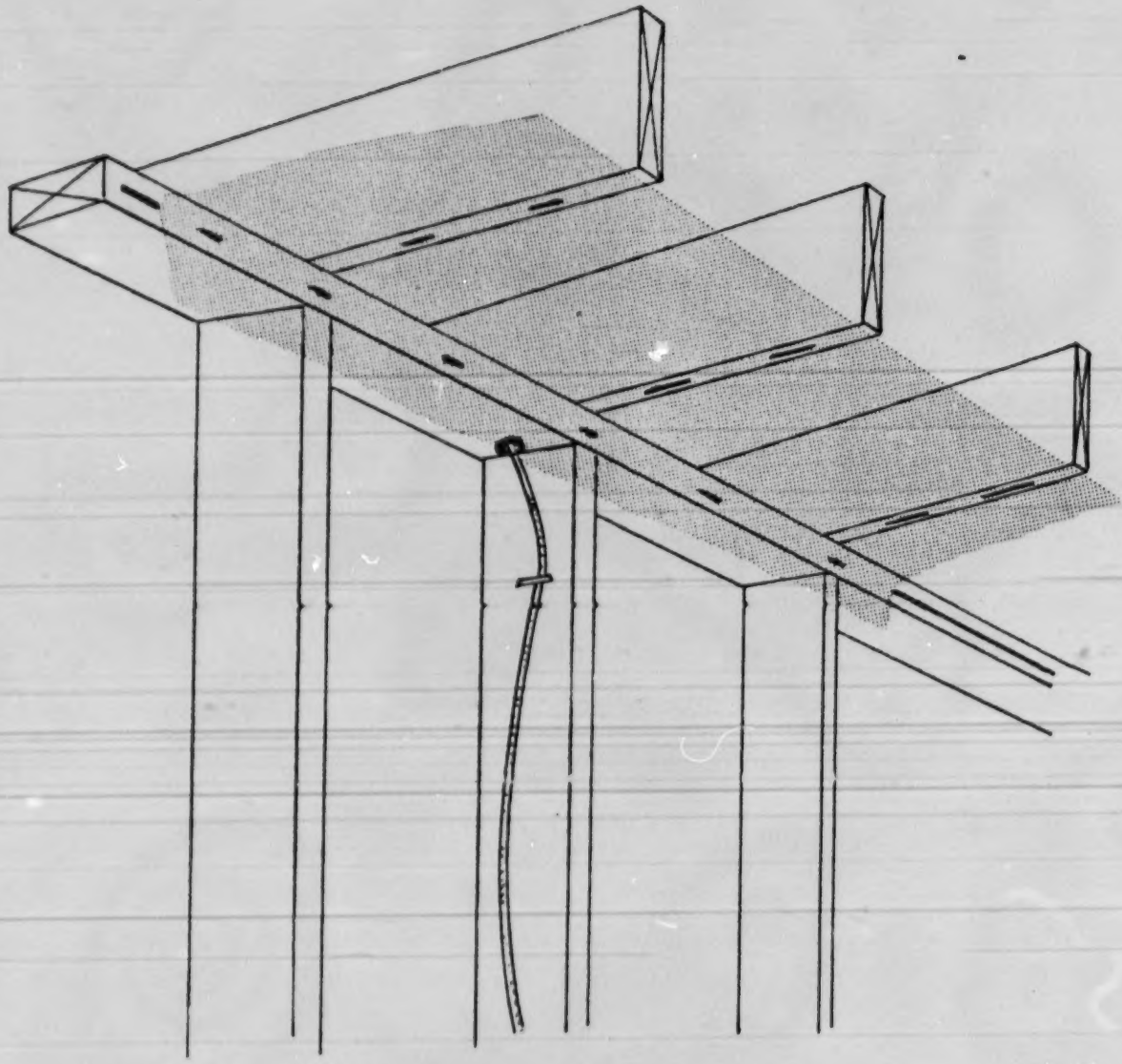


FIGURE III - 4

VAPOR BARRIER FOR PARTITION WALL AND SINGLE TOP PLATE

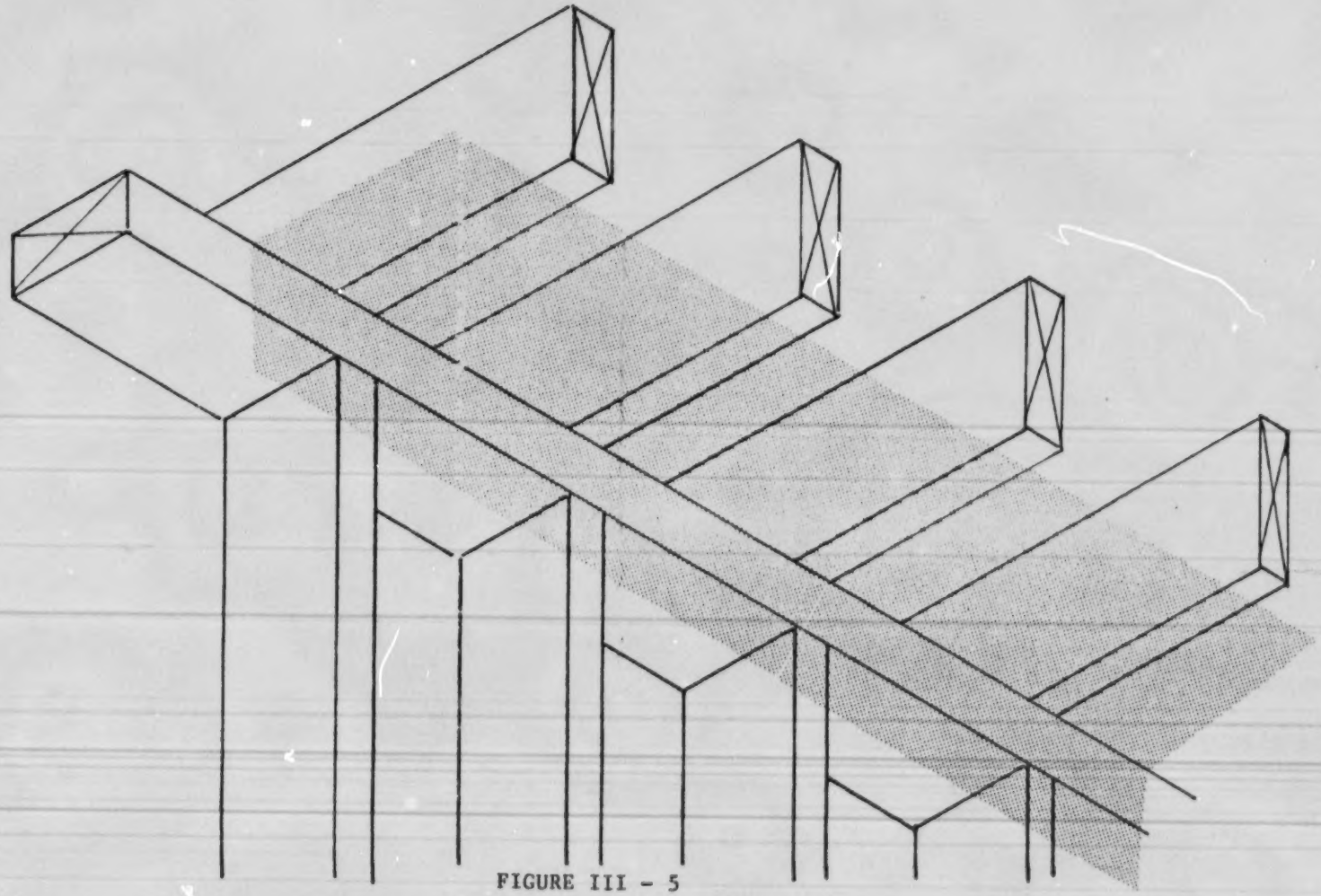


FIGURE III - 5

INTERIOR CEILING VAPOR BARRIER WITH SINGLE TOP PLATE

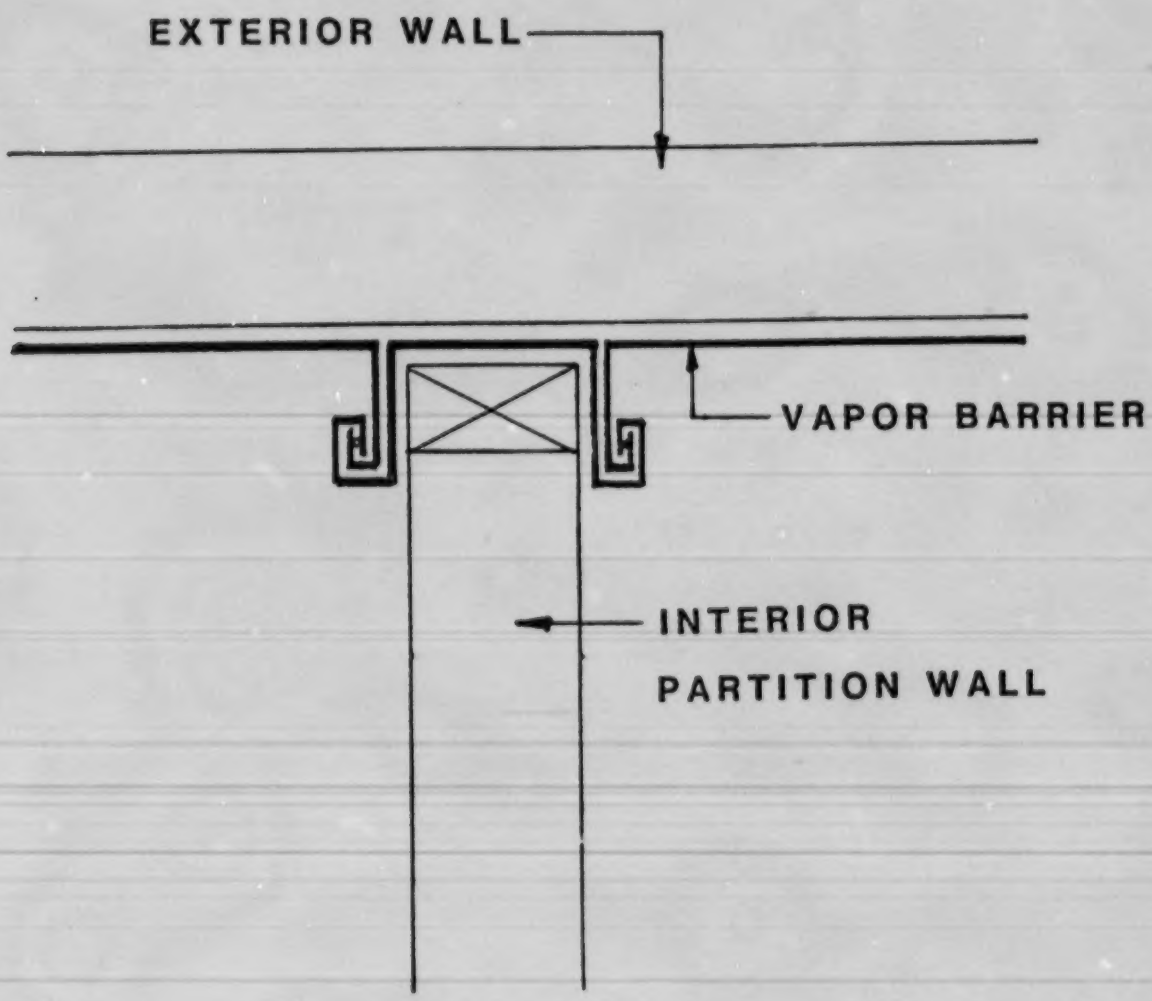
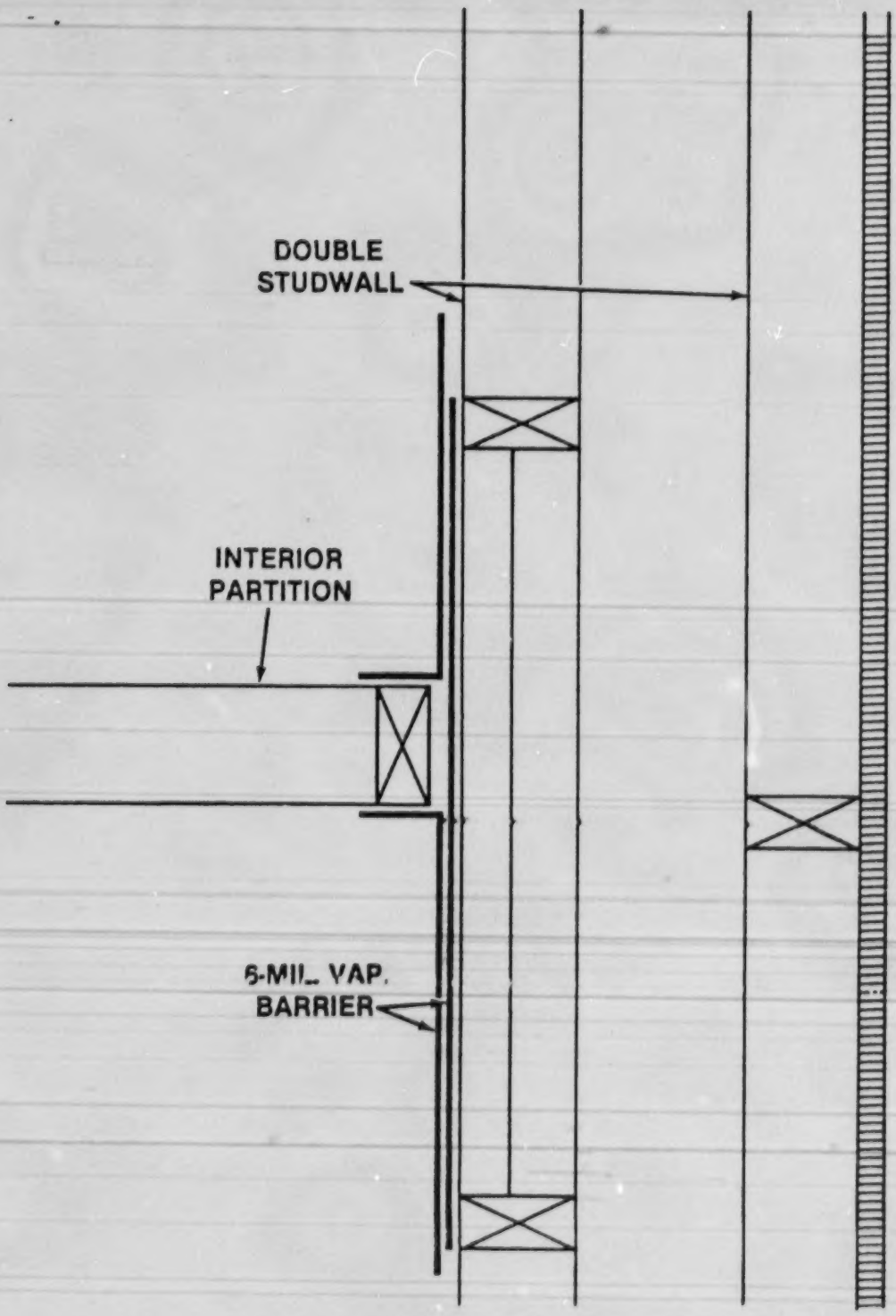


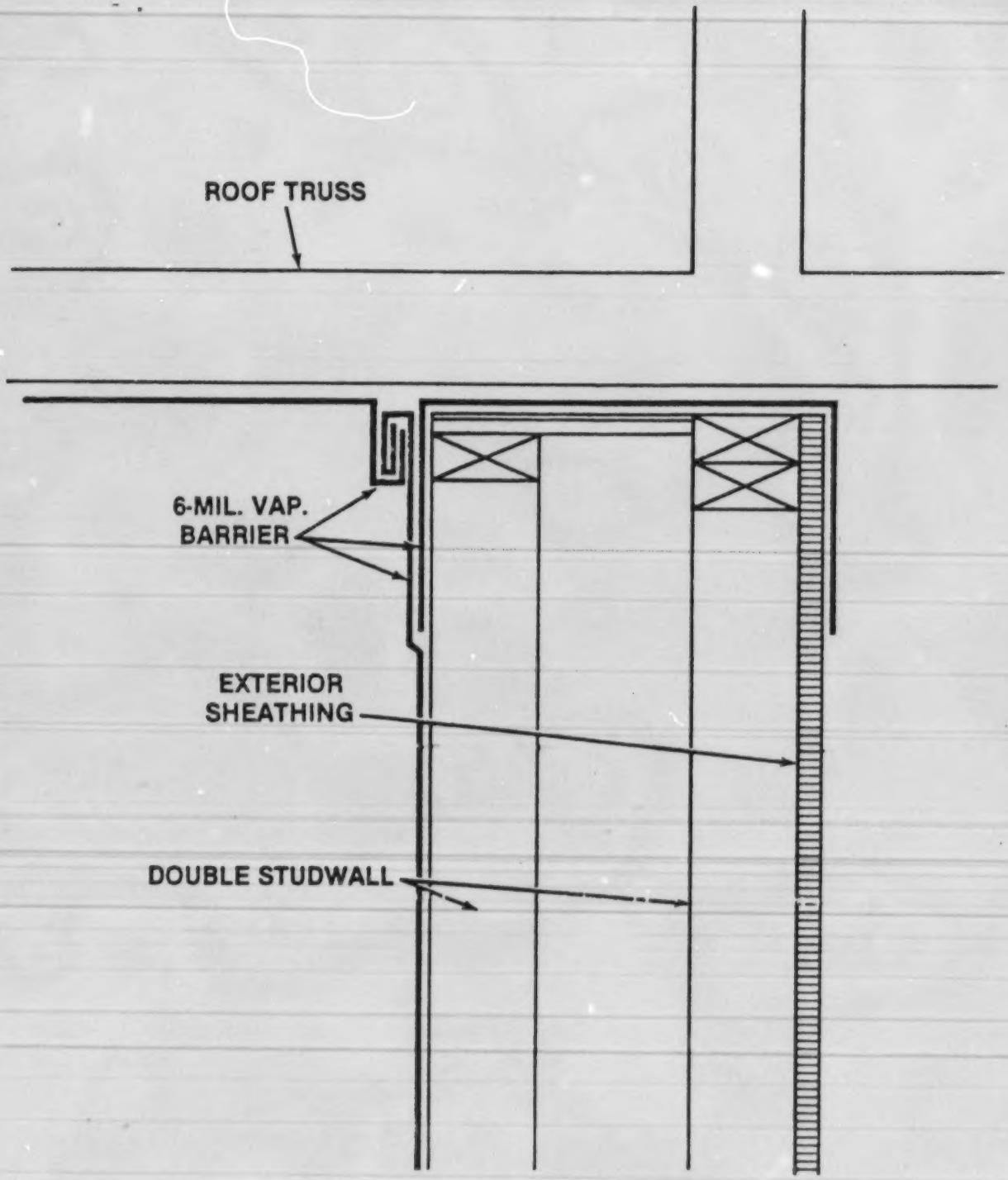
FIGURE III - 6

VAPOR BARRIER AT INTERIOR AND EXTERIOR WALLS



VAPOR BARRIER AT INTERIOR AND EXTERIOR WALLS

FIGURE III - 7



VAPOR BARRIER AT WALL AND TRUSS

FIGURE III - 8

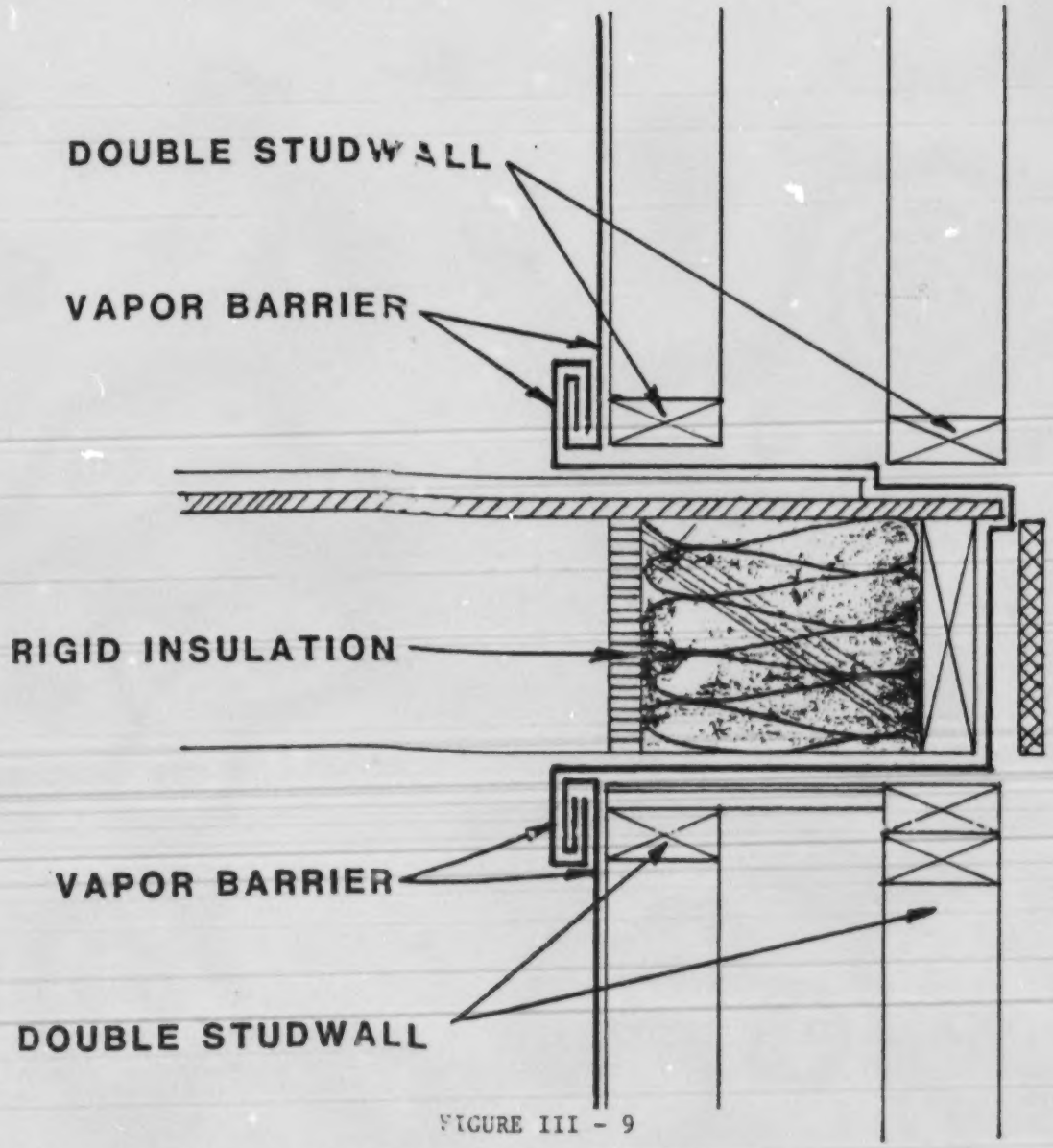
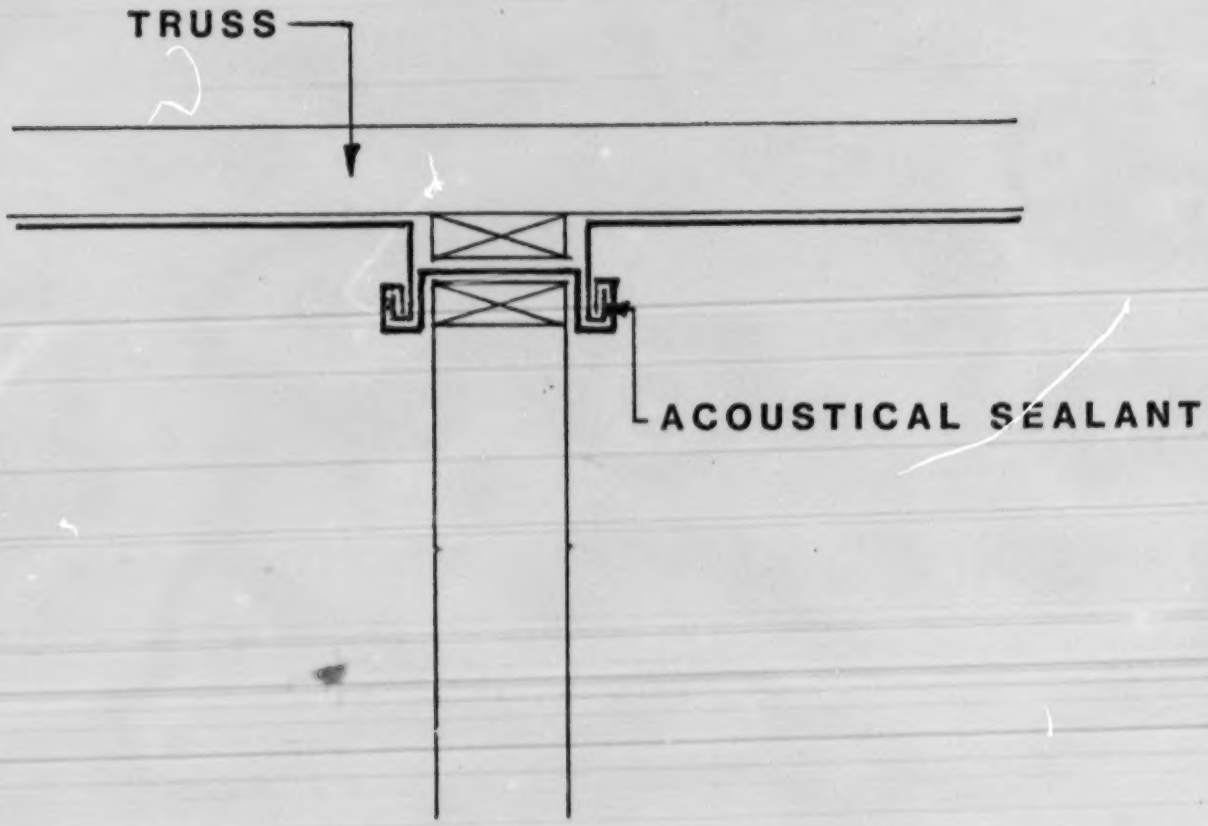


FIGURE III - 9

A 16 to 20 inch vapor barrier piece should be placed over the top plate of the double wall. All lapped pieces should be sealed against solid blocking placed between the framing members.

III - 15

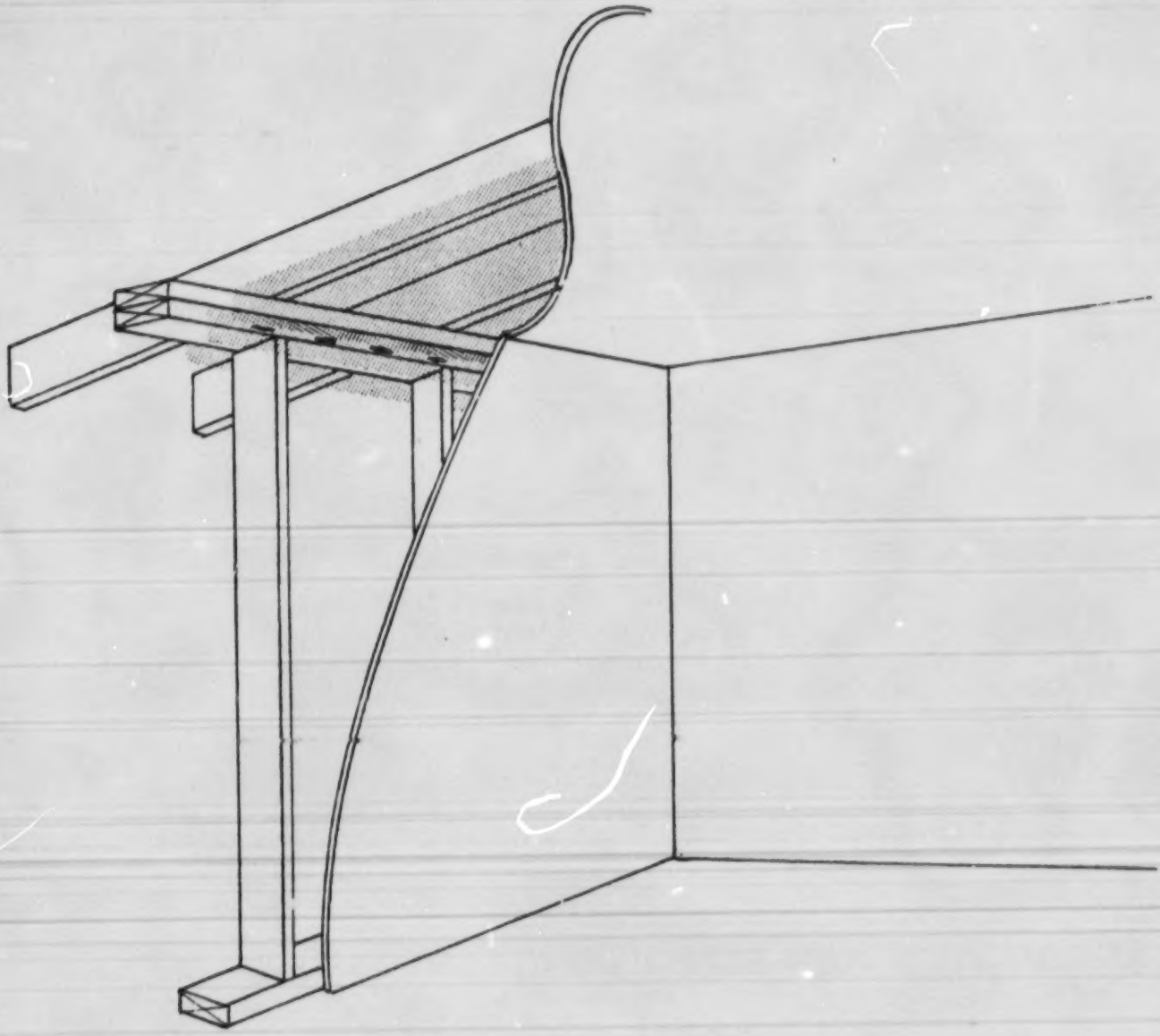
VAPOR BARRIER AT WALL AND FLOOR



It is better to extend the vapor barrier lap down from the ceiling and place it under the wall vapor barrier so that any condensation is diverted into the wall cavity rather than allowing it to stain ceiling or wall surfaces.

FIGURE III - 10

VAPOR BARRIER AT INTERIOR WALL AND TRUSS



A 16" vapor barrier strip is sandwiched between two top plates of partition wall during framing to join ceiling vapor barrier.

FIGURE III - 11

VAPOR BARRIER CONTINUITY MAINTENANCE

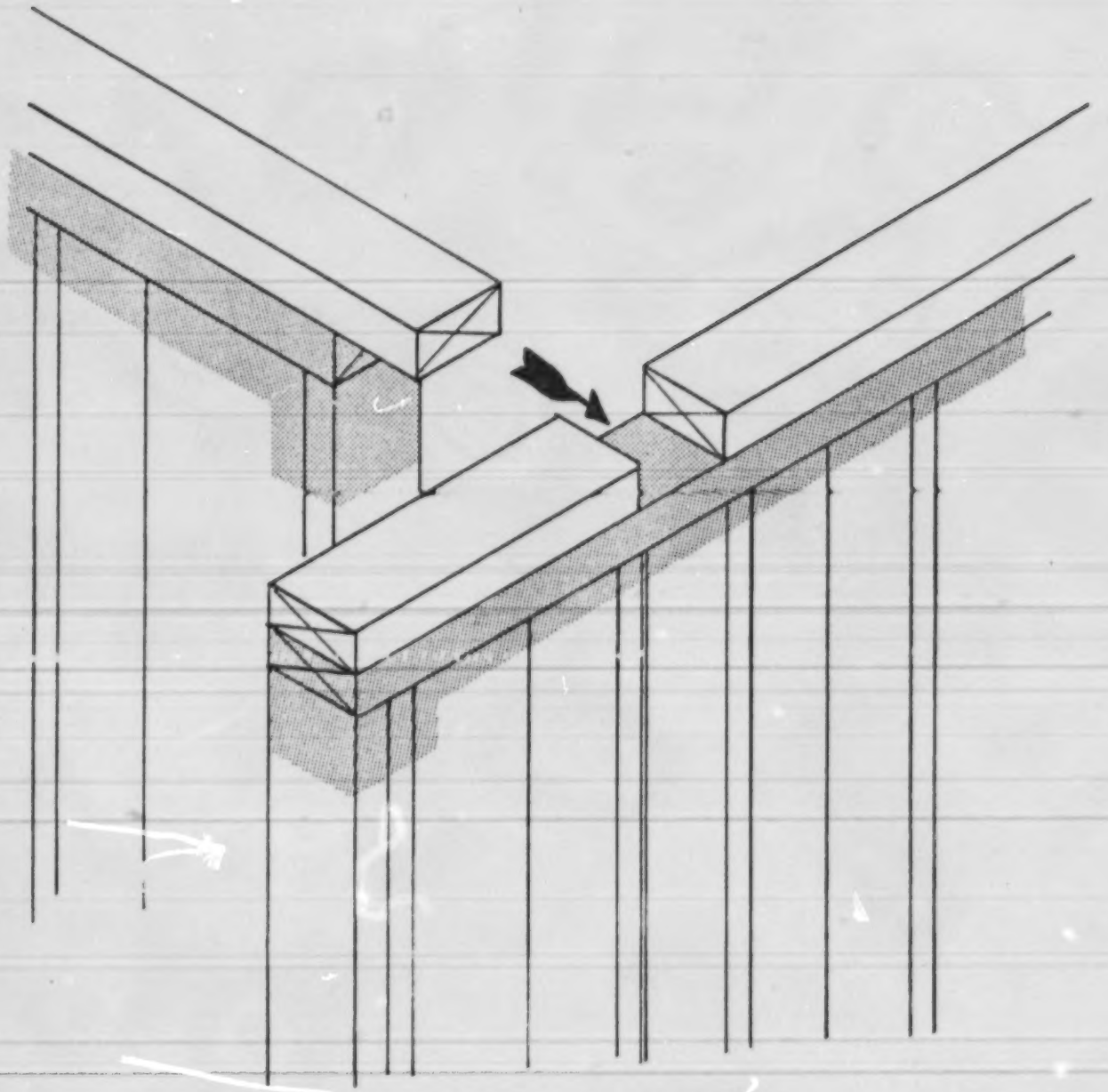


FIGURE III - 12

INTERIOR CEILING VAPOR BARRIER WITH DOUBLE BLOCKING

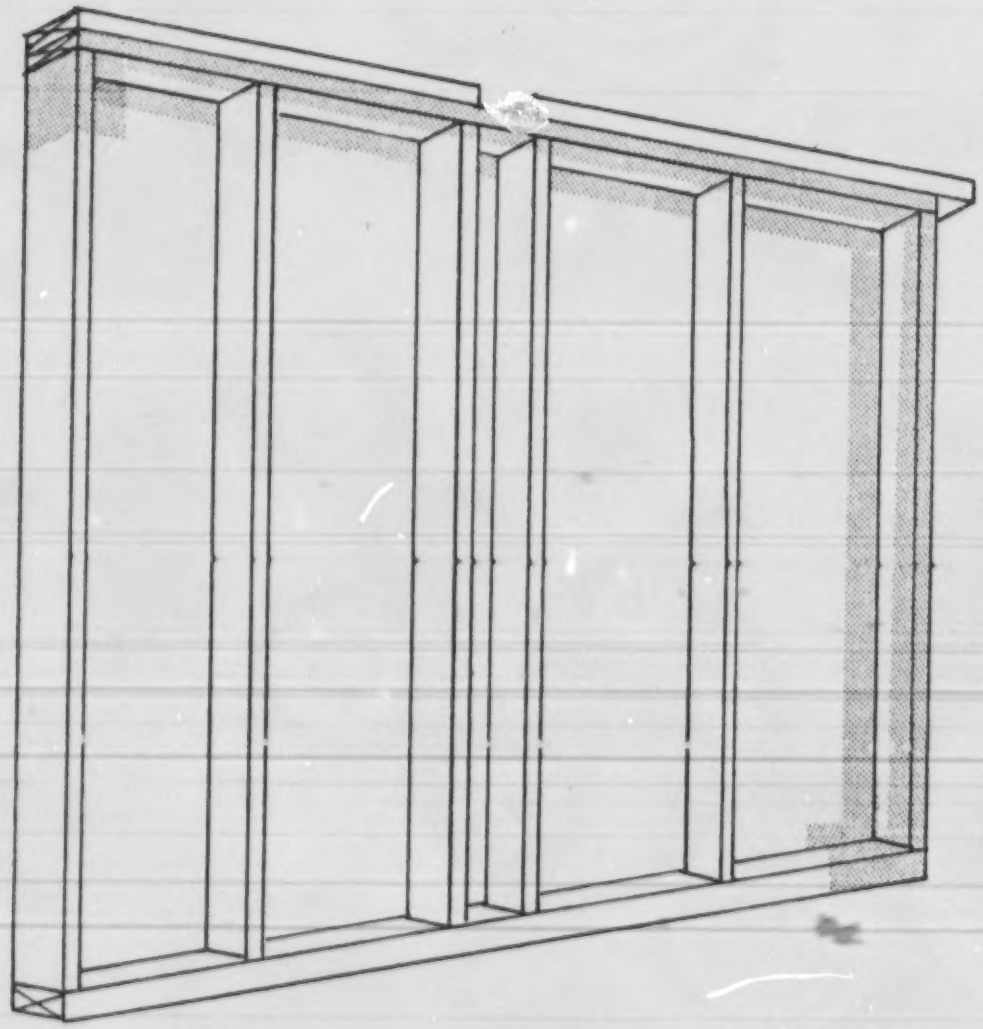


FIGURE III - 13

VAPOR BARRIER INSTALLATION AT WALL AND CEILING FOR INTERIOR PARTITION

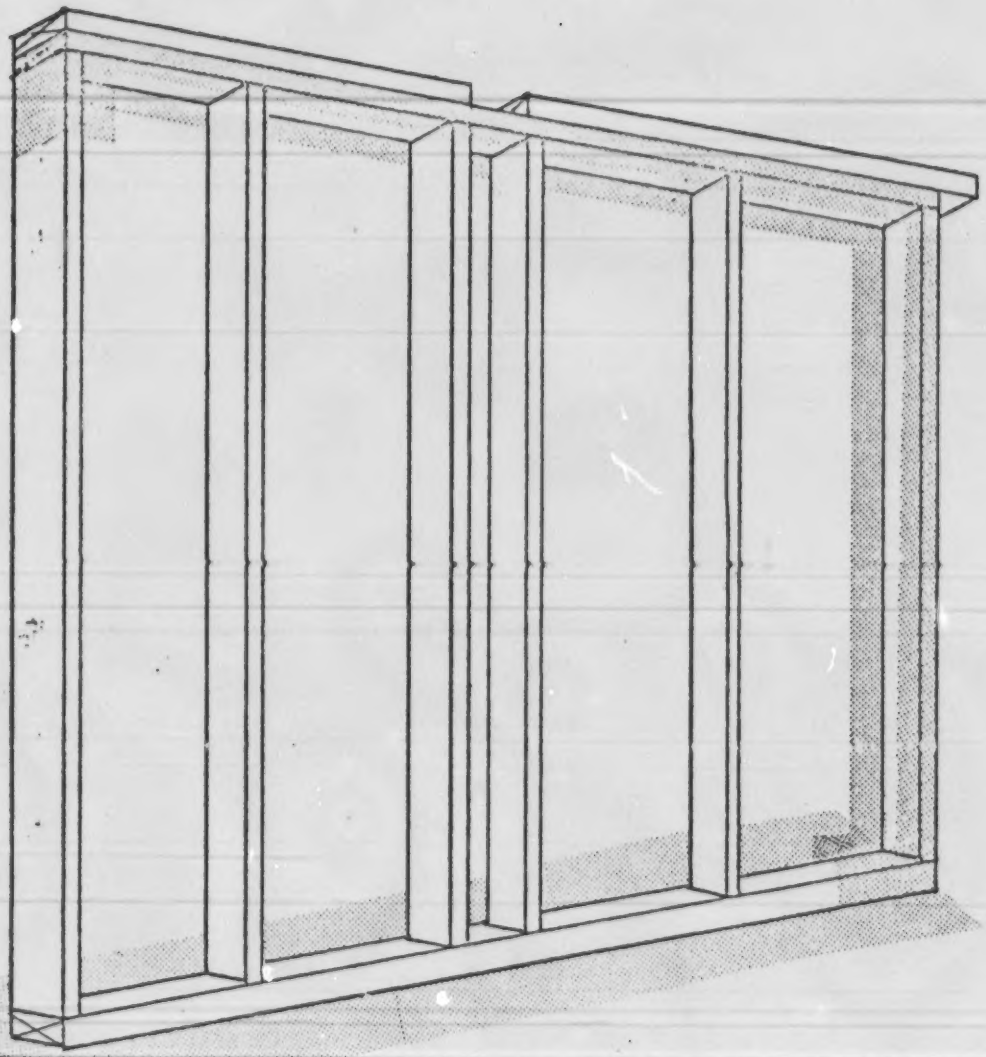


FIGURE III - 14

VAPOR BARRIER INSTALLATION FOR INTERIOR PARTITION OVER CRAWL SPACE

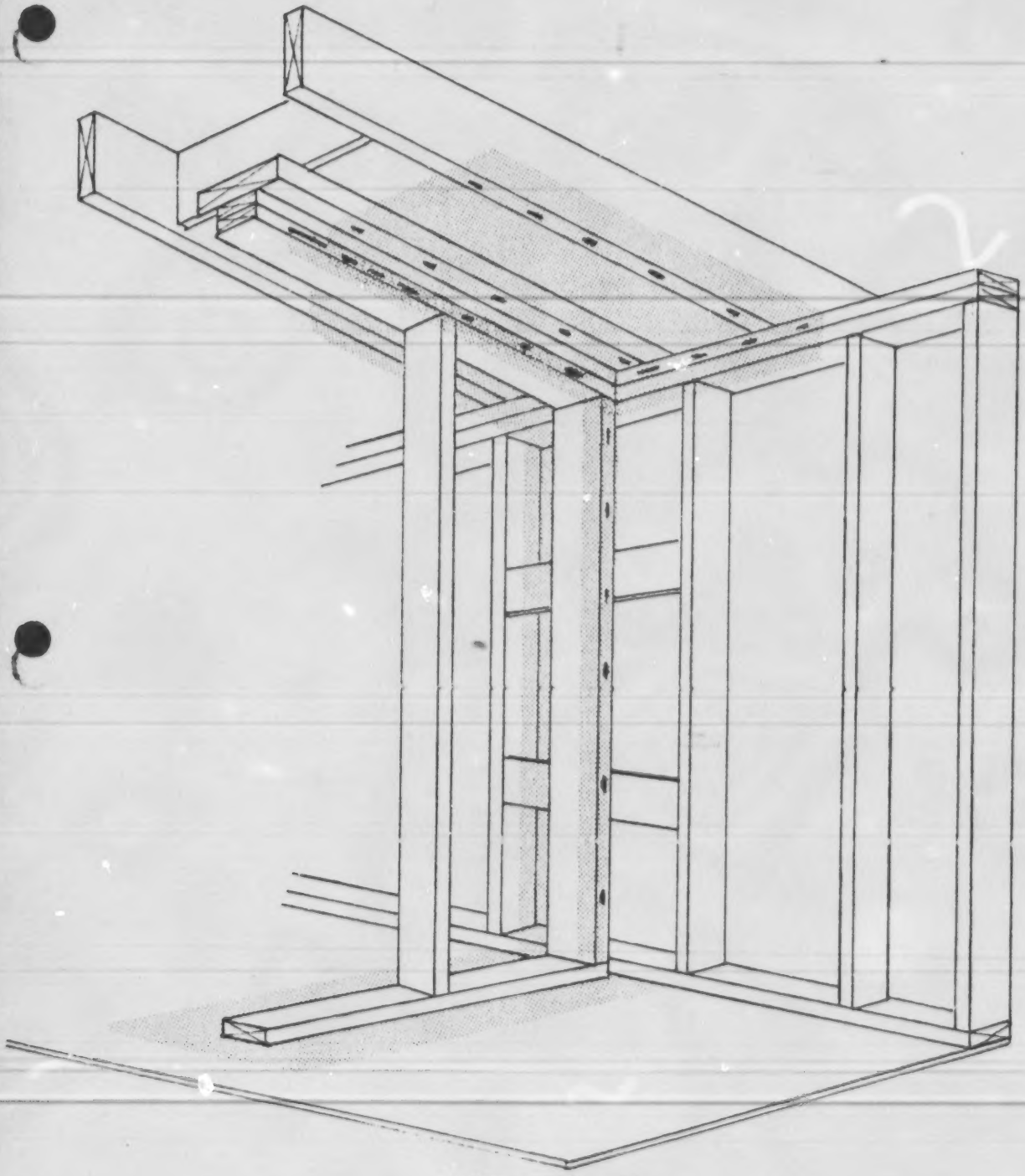


FIGURE III - 15

VAPOR BARRIER INSTALLATION FOR INTERIOR PARTITION OVER CRAWL SPACE

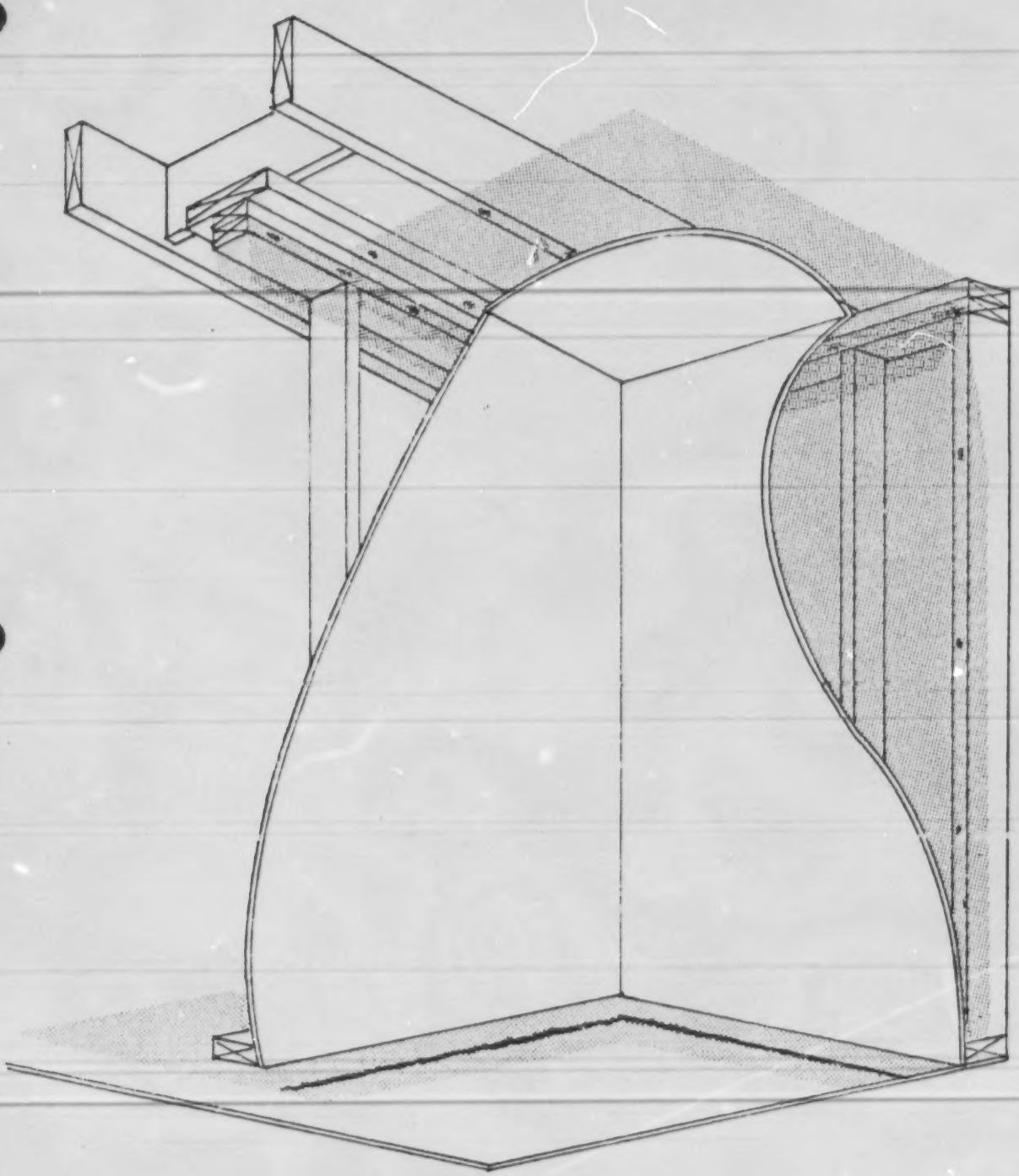
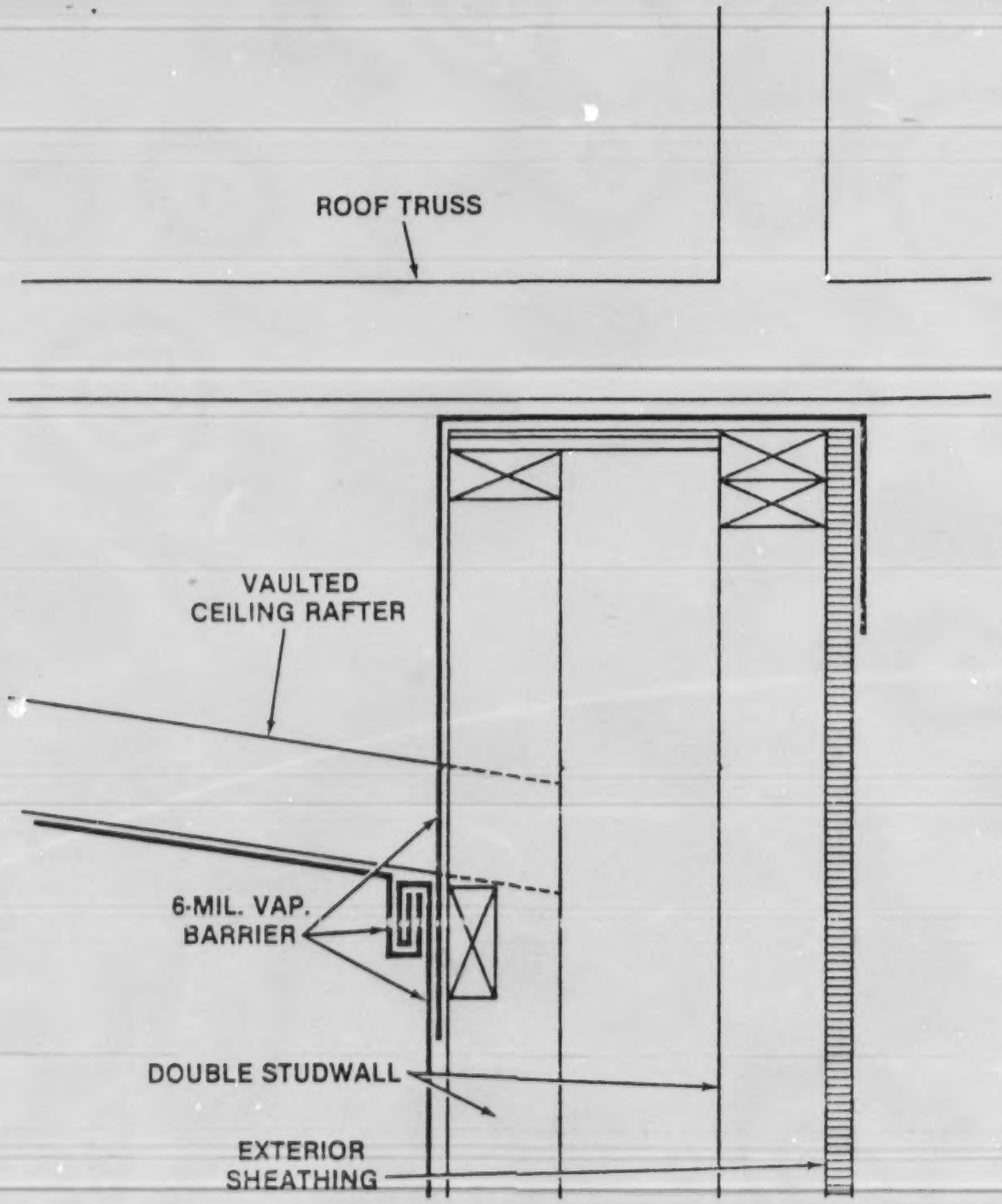


FIGURE III - 16

VAPOR BARRIER AT PARTITION WALL AND CEILING



VAPOR BARRIER AT WALL AND VAULTED CEILING

FIGURE III - 17

In split level homes, the upper portion of the adjacent wall to the cold attic cavity should be vapor-proofed and insulated as if it were a full wall. Suitable blocking should be installed between the studs for sealing the vapor barrier and isolating the warm and cold portions of the wall.

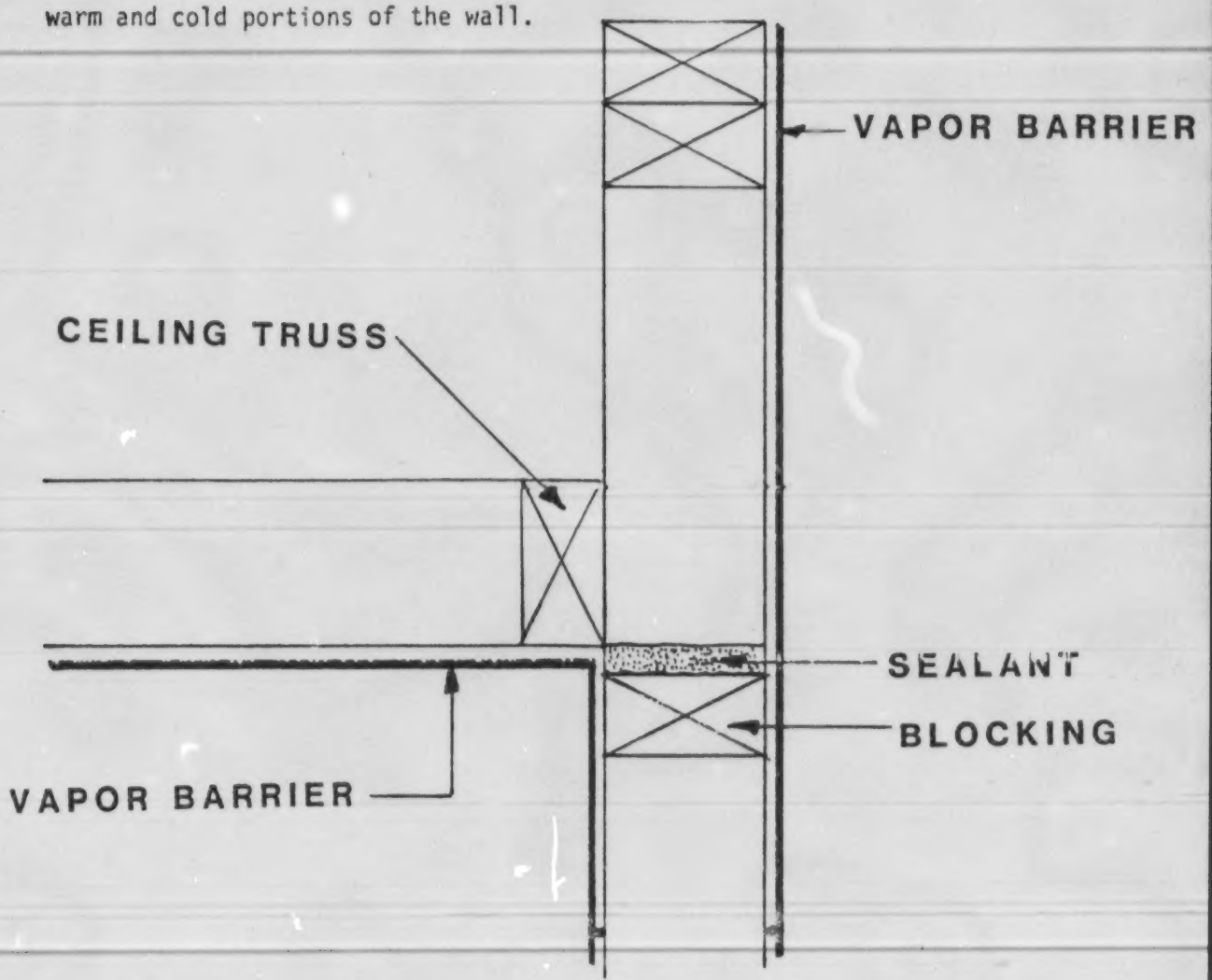


FIGURE III - 18

VAPOR BARRIER AT SPLIT LEVEL CEILING CORNERS

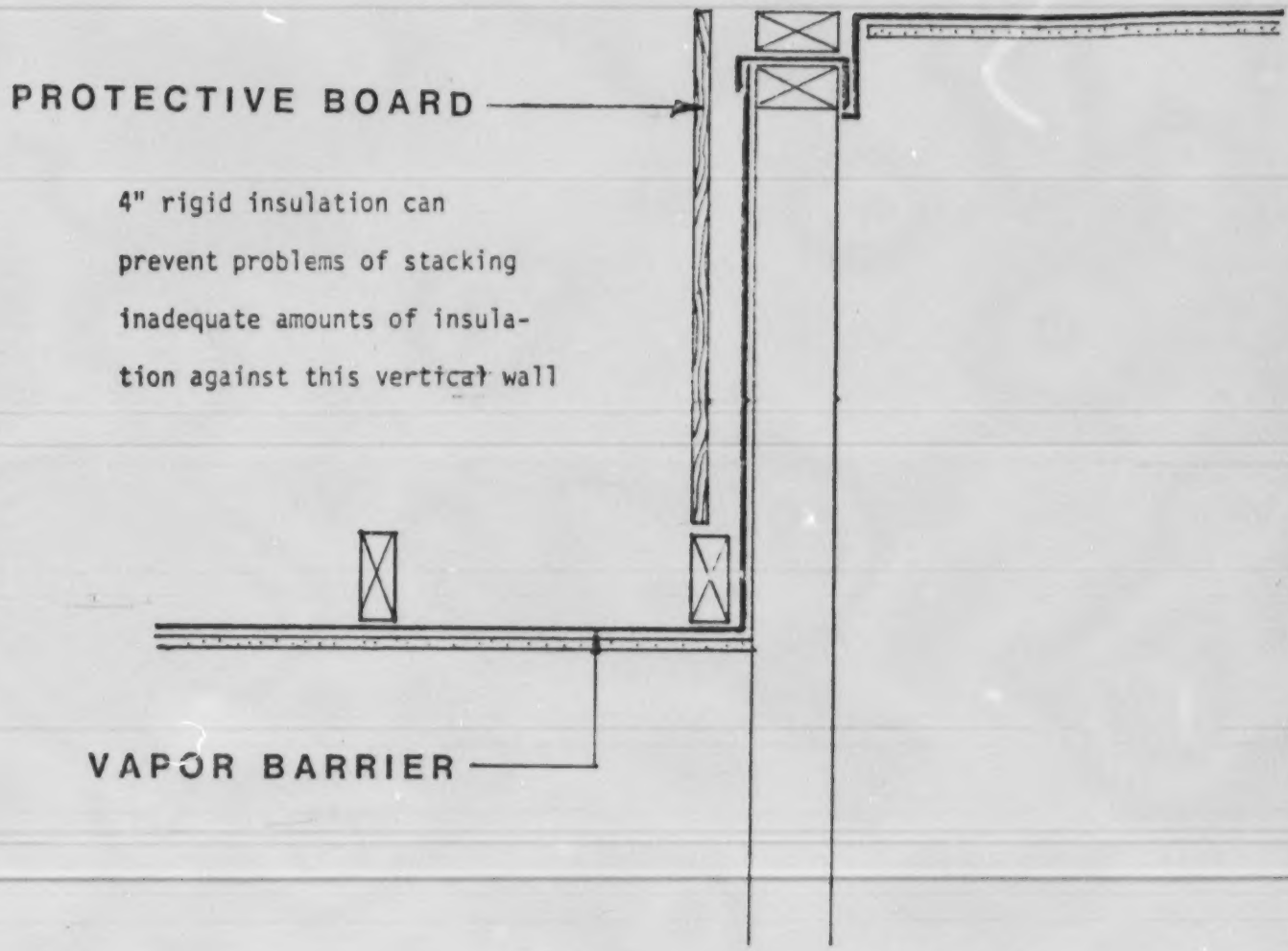

PROTECTIVE BOARD
4" rigid insulation can prevent problems of stacking inadequate amounts of insulation against this vertical wall
VAPOR BARRIER

FIGURE III - 19

VAPOR BARRIER AT SPLIT LEVEL CEILING CORNERS

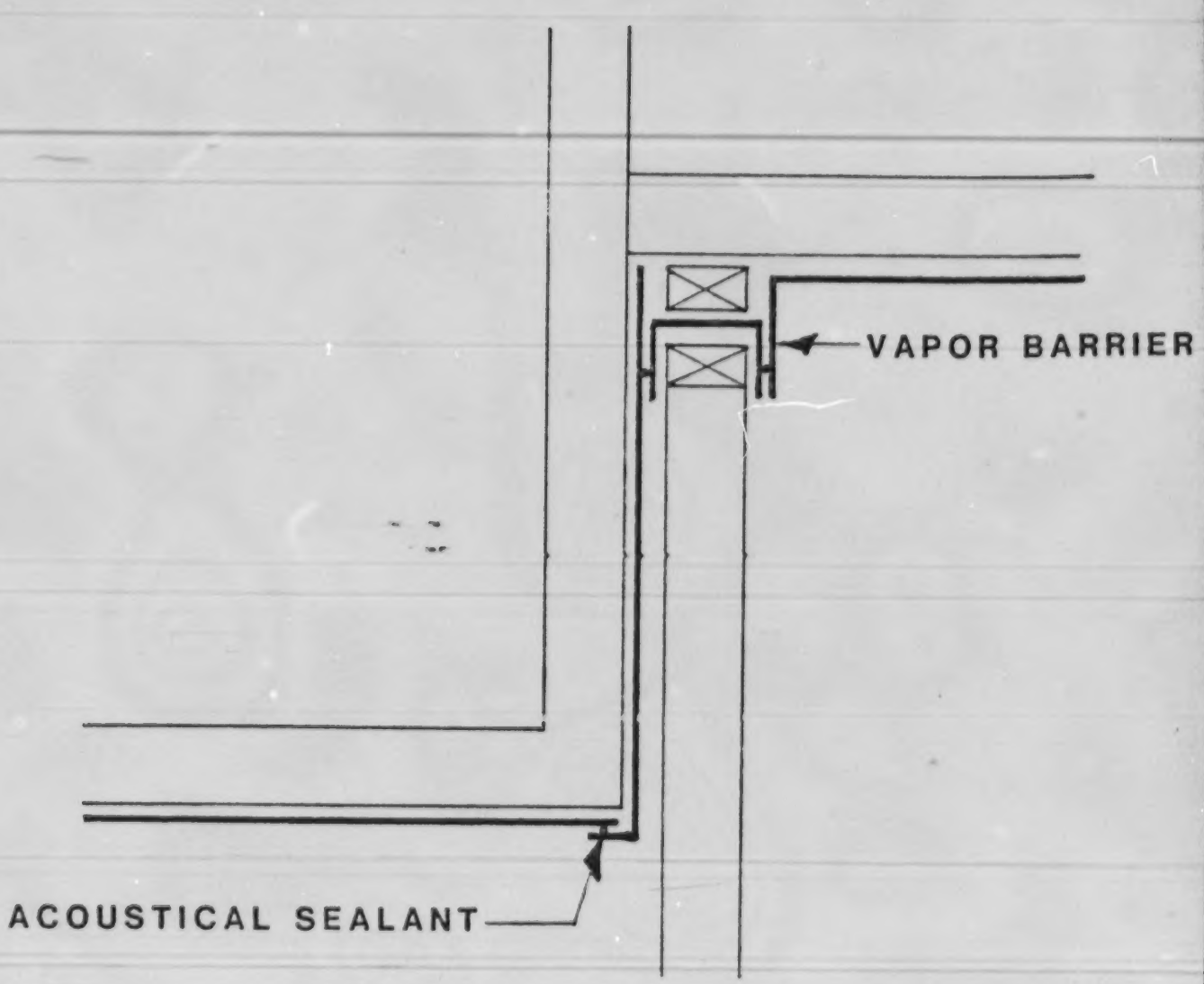


FIGURE III - 20

VAPOR BARRIER AT SPLIT LEVEL CORNERS

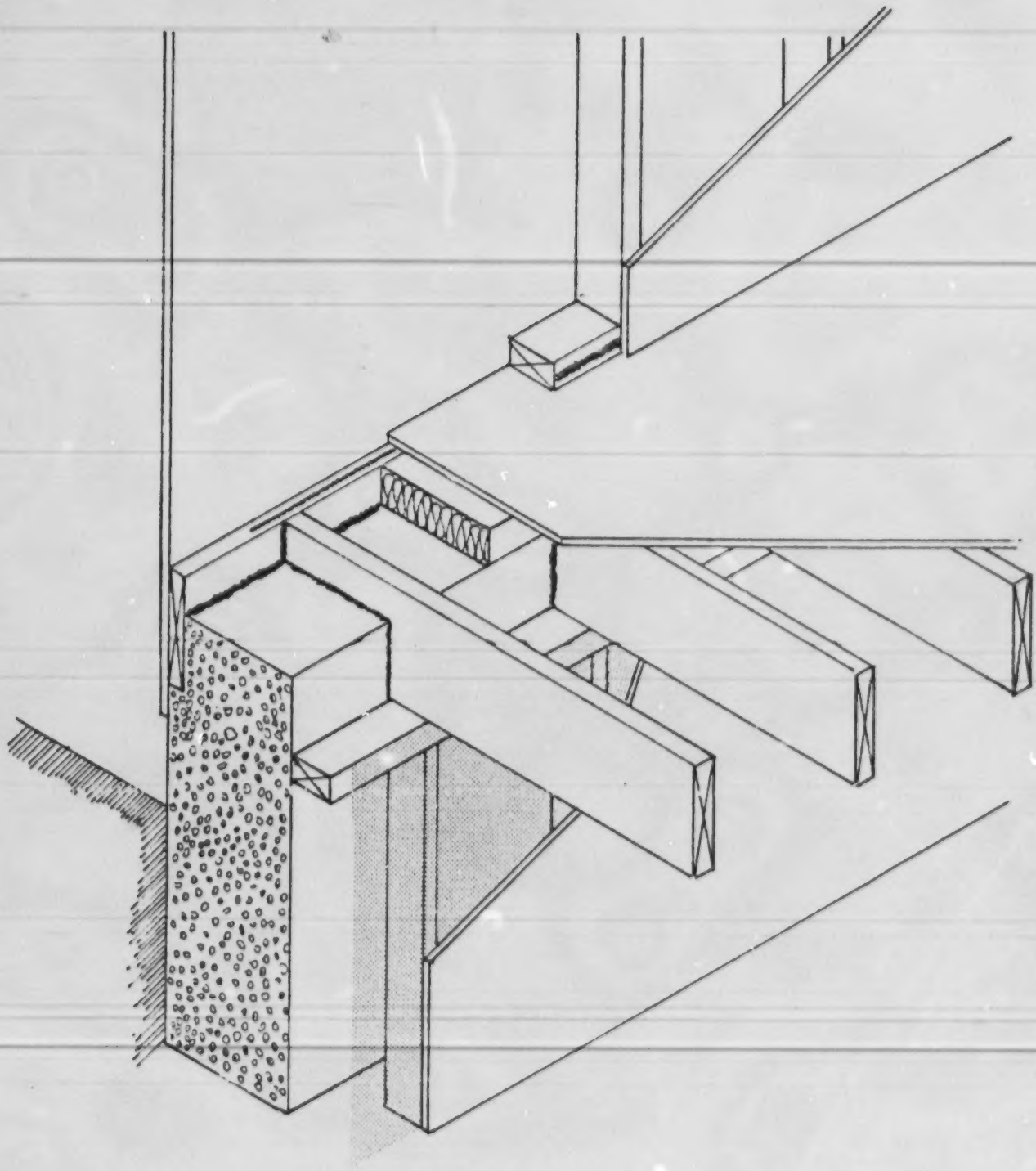


FIGURE III - 21

BASEMENT INTERIOR STUDWALL VAPOR BARRIER INSTALLATION

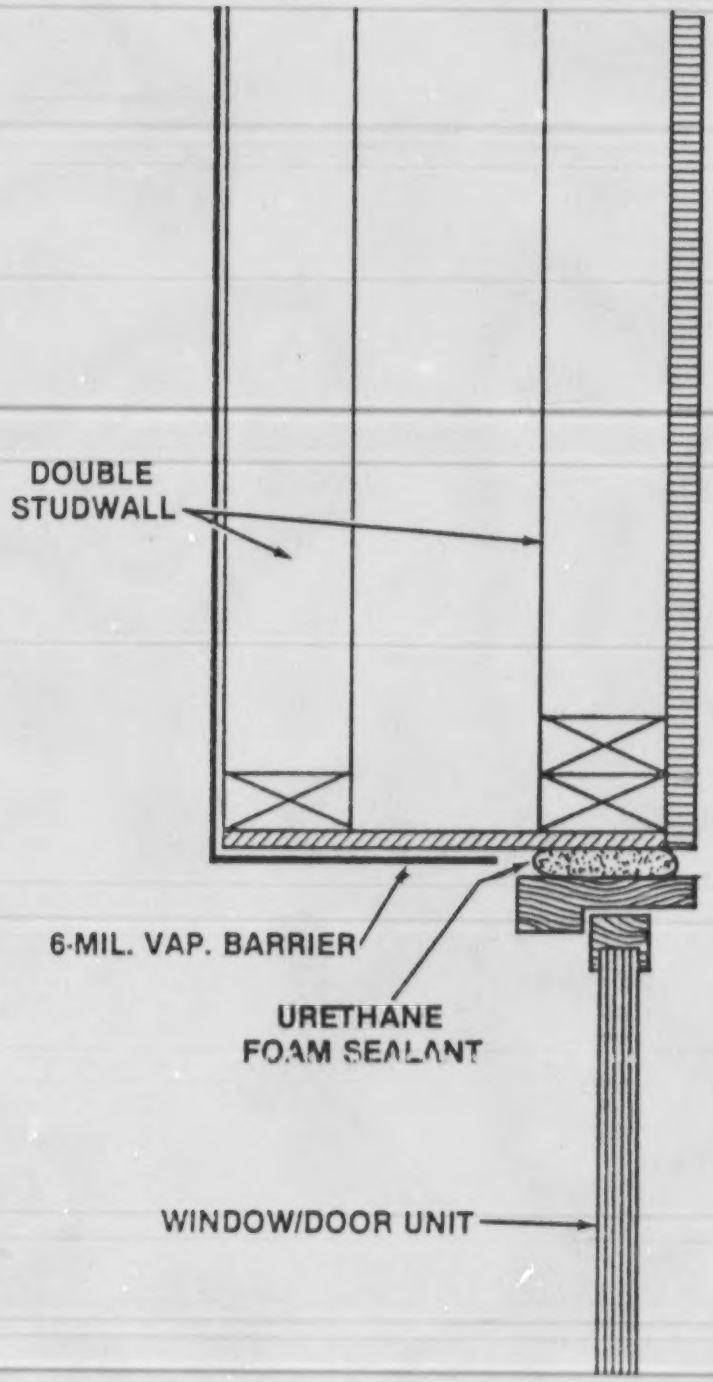
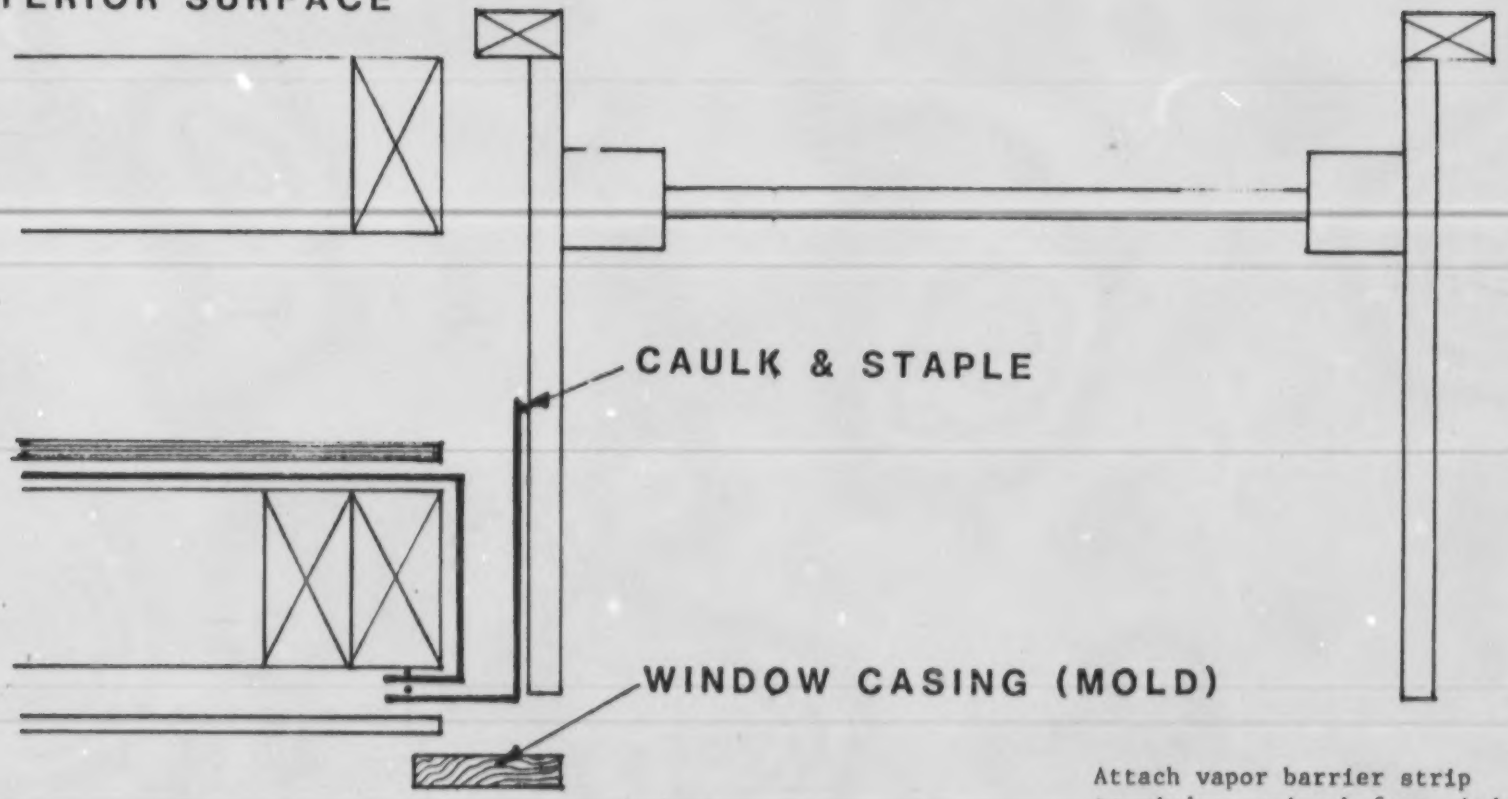


FIGURE III - 22

VAPOR BARRIER AND SEALANT AT WINDOWS AND DOORS



Attach vapor barrier strip to window casing before window is inserted into rough opening. Allow plenty of material at corners to fold over framing.

FIGURE III - 23

WINDOW DETAIL - CANADIAN DOUBLE WALL

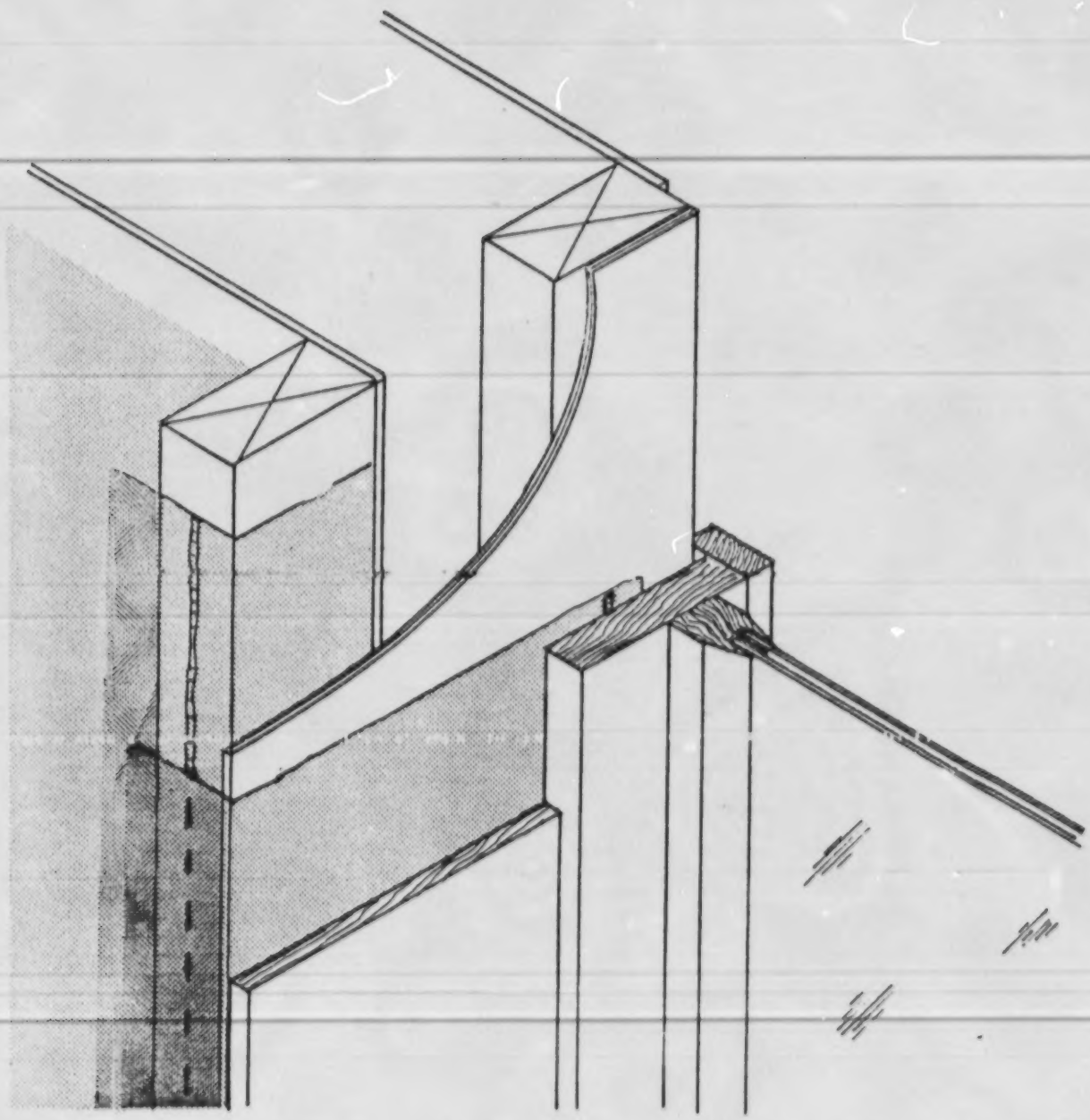
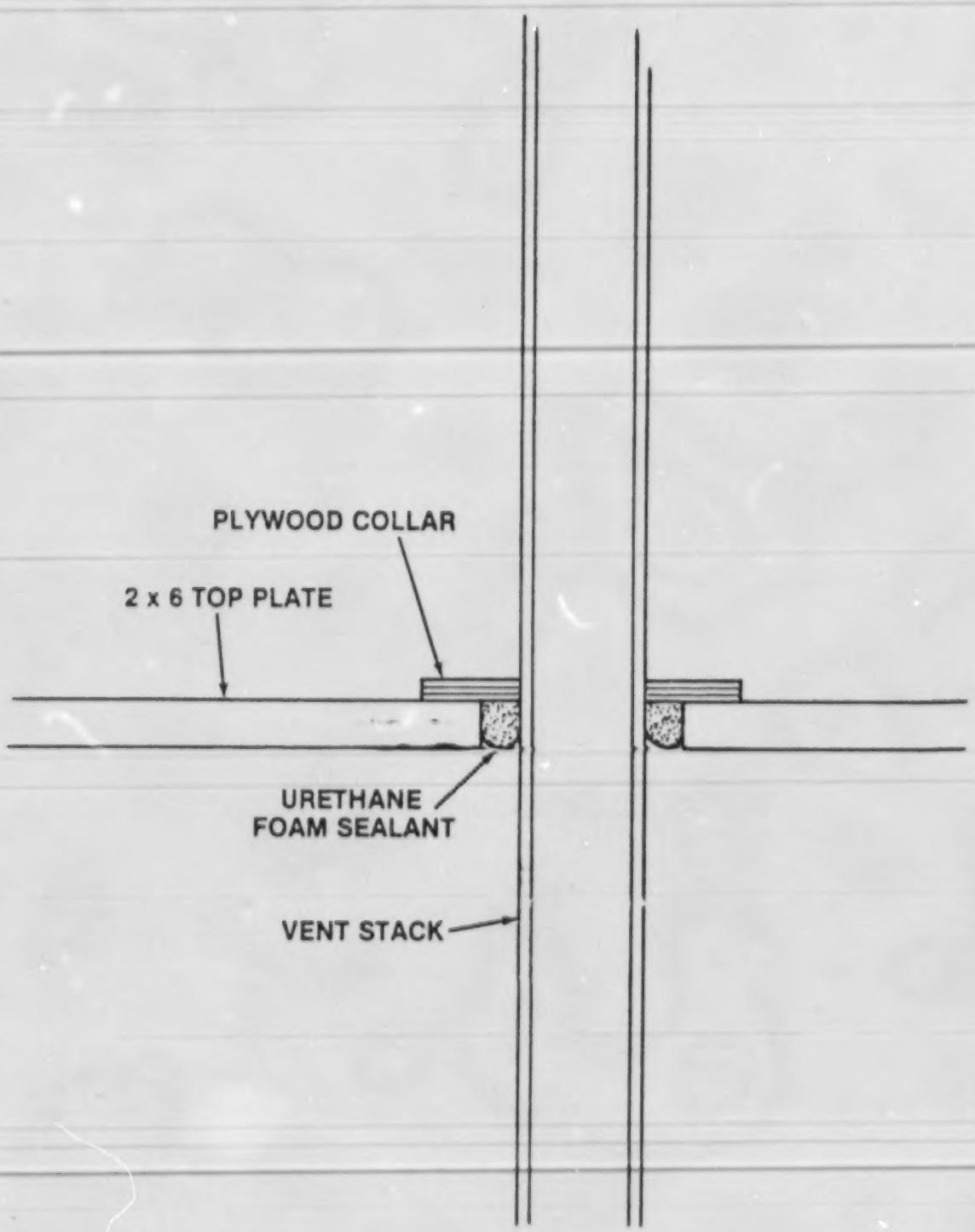


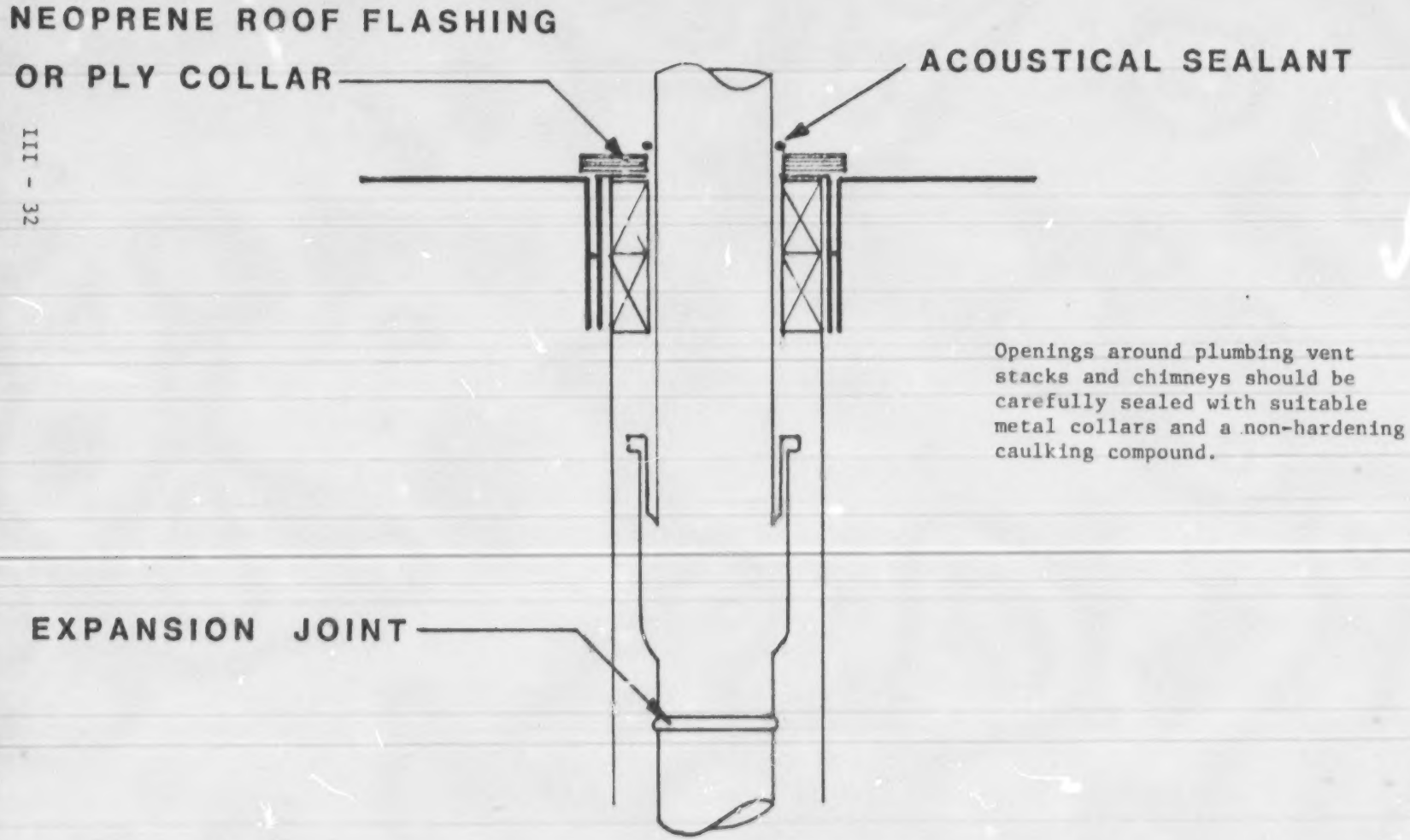
FIGURE III - 24

WINDOW VAPOR BARRIER DETAIL FOR DOUBLE WALL CONSTRUCTION



SEALING THE VENT PIPE

FIGURE III - 25



Openings around plumbing vent stacks and chimneys should be carefully sealed with suitable metal collars and a non-hardening caulking compound.

FIGURE III - 26

VAPOR BARRIER INSTALLATION AROUND PLUMBING VENT STACK

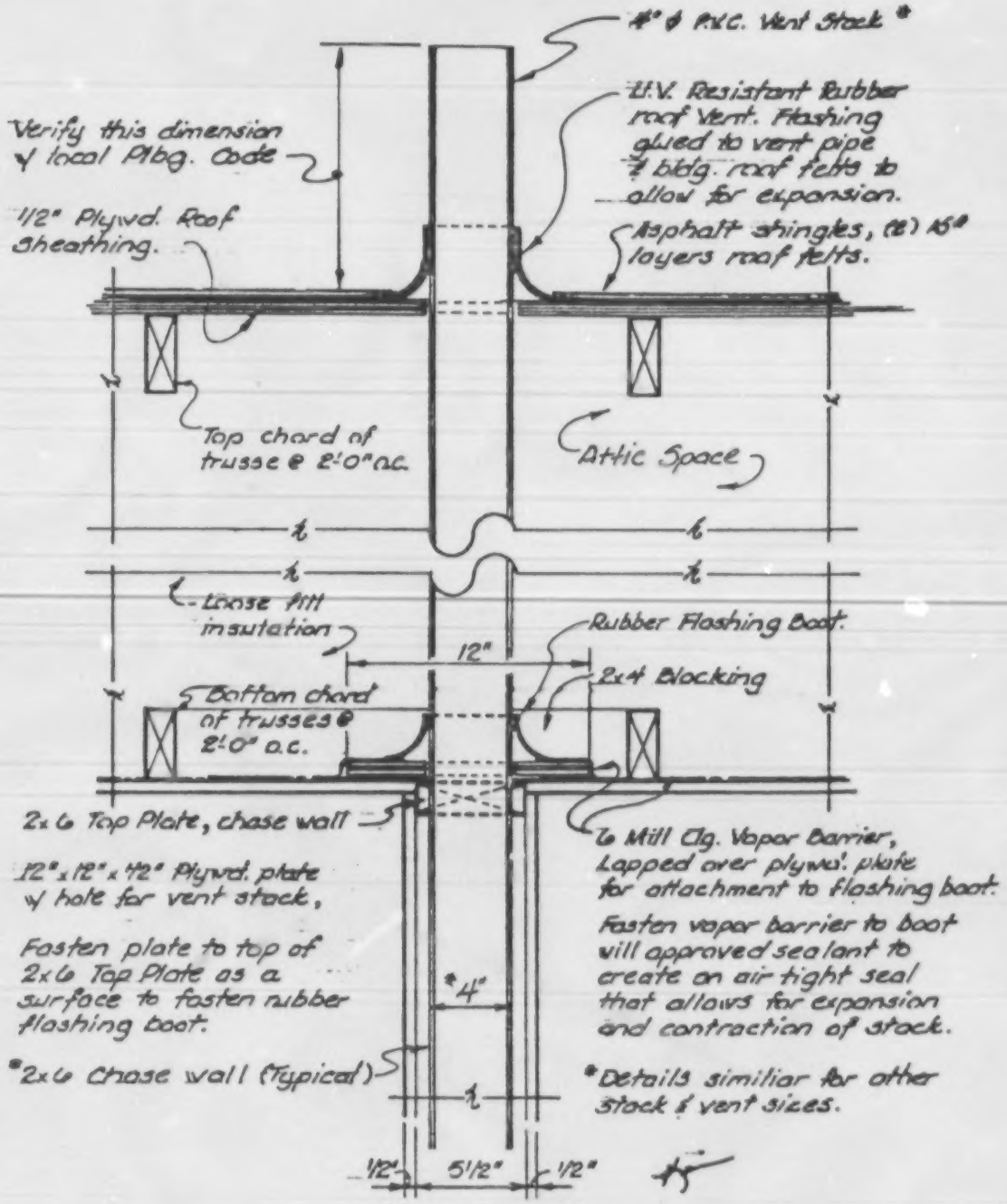

4" ϕ P.V.C. Vent Stack *
U.V. Resistant Rubber roof Vent. Flashing glued to vent pipe & bldg. roof felts to allow for expansion.
Verify this dimension w/ local Plbg. Code
1/2" Plywd. Roof Sheathing.
Asphalt shingles, (2) 15# layers roof felts.
Top chord of trusse @ 2'-0" o.c.
Attic Space
Loose fill insulation
Rubber Flashing Boot.
12"
2x4 Blocking
Bottom chord of trusses @ 2'-0" o.c.
2x6 Top Plate, chase wall
To Mill Clg. Vapor Barrier, Lapped over plywd. plate for attachment to flashing boot.
12" x 12" x 1/2" Plywd. plate w/ hole for vent stack,
Fasten plate to top of 2x6 Top Plate as a surface to fasten rubber flashing boot.
Fasten vapor barrier to boot will approved sealant to create an air tight seal that allows for expansion and contraction of stack.
*4"
*2x6 Chase wall (Typical)
*Details similiar for other stack & vent sizes.
1/2"
5 1/2"
1/2"

FIGURE III - 27

VENT STACK DETAIL

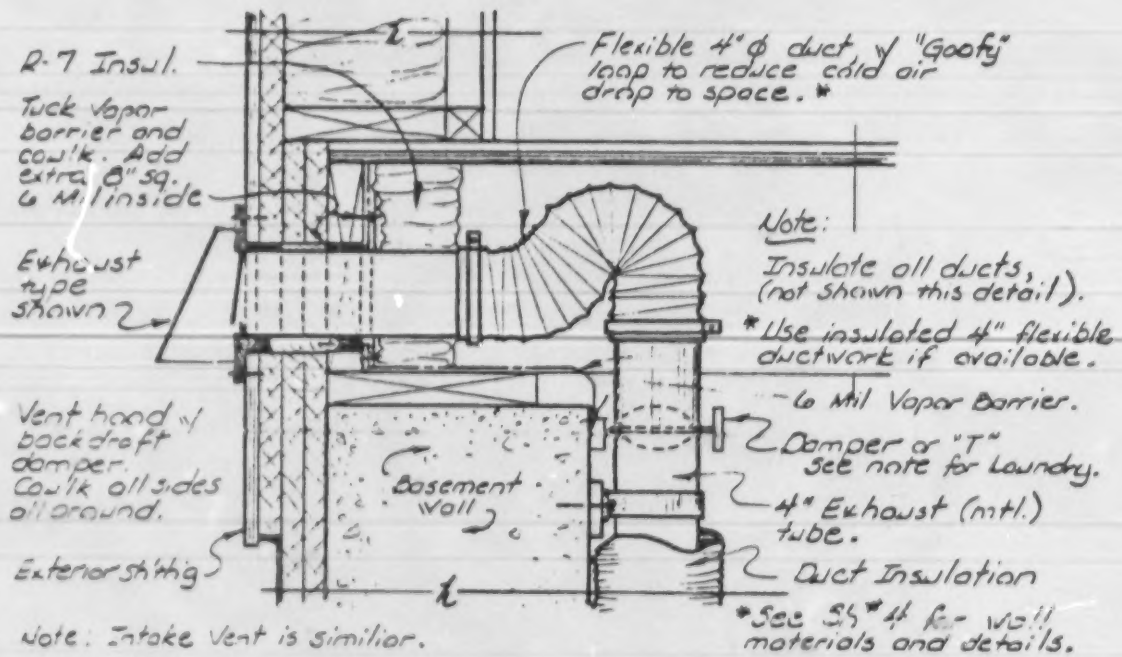
SCALE: 1½" = 1'-0"

MINNESOTA ENERGY AGENCY – SUPER INSULATED HOME DEMONSTRATION PROJECT

DRAWING TITLE: PLUMBING VENT STACK DETAIL DRAWING NUMBER SI-2

DRAWN BY: KWH DATED: 3/1/82 SCALE: 1½"=1'-0" REFERENCE: D-2

980 American Center Bldg., 150 East Kellogg Blvd., St. Paul, Minnesota 55101


R-7 Insul.
Tuck Vapor barrier and caulk. Add extra 8" sq. 6 Mil inside
Exhaust type shown
Vent hood w/ back draft damper. Caulk all sides all around.
Exterior Shthg
Basement Wall
Flexible 4" ϕ duct w/ "Goofy" loop to reduce cold air drop to space. *
Note:
Insulate all ducts, (not shown this detail).
* Use insulated 4" flexible ductwork if available.
6 Mil Vapor Barrier.
Damper or "T" see note for Laundry.
4" Exhaust (mtl.) tube.
Duct Insulation
* See SI-4 for wall materials and details.
Note: Intake Vent is similar.

WALL VENT DETAIL

Scale: 1½" = 1'-0"

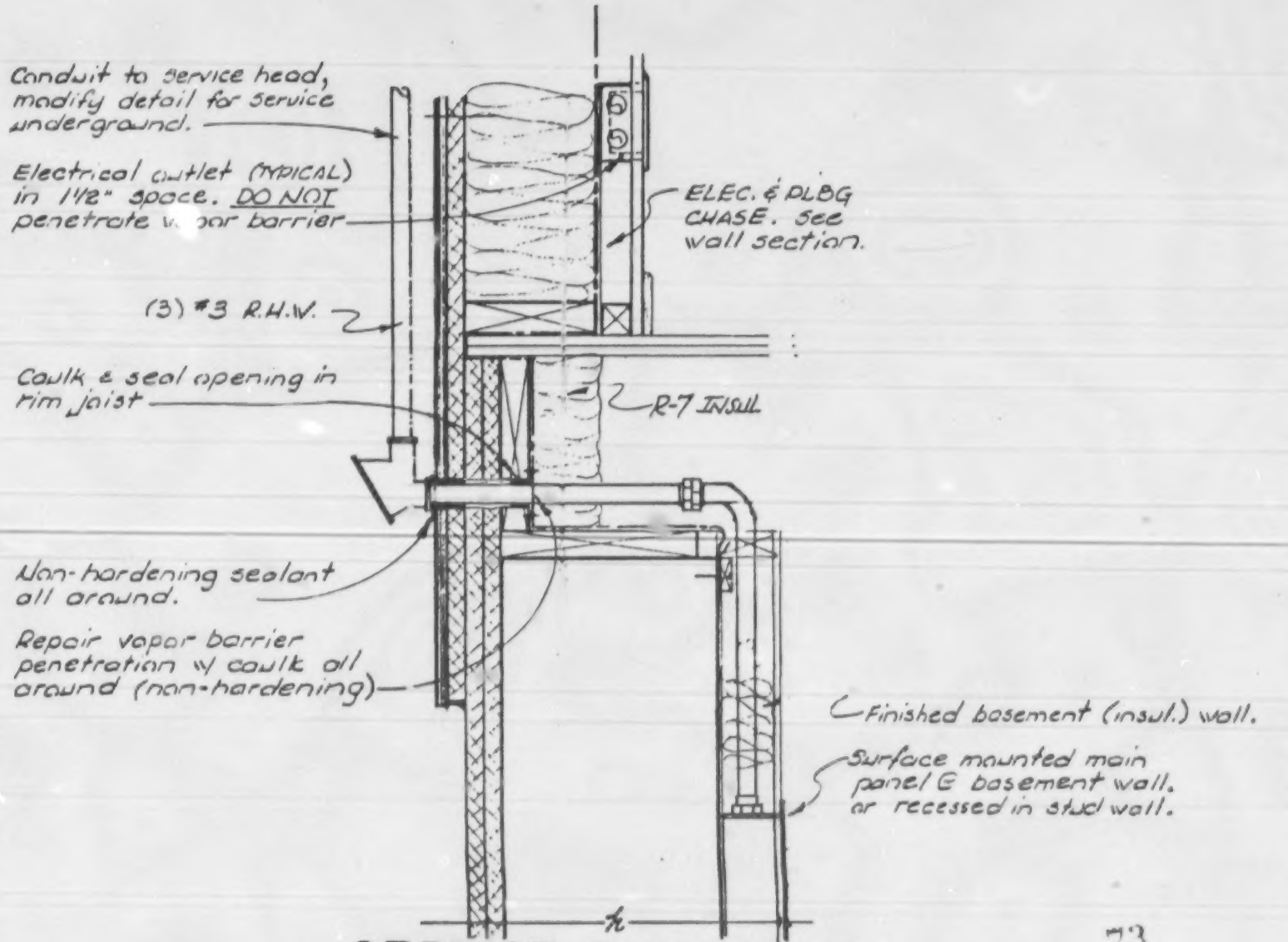
FIGURE III - 28

MINNESOTA ENERGY AGENCY - SUPER INSULATED HOME DEMONSTRATION PROJECT

DRAWING TITLE: WALL VENT DETAIL DRAWING NUMBER SI-22

DRAWN BY: [illegible] DATED: 3/2/82 SCALE: 1½" = 1'-0" REFERENCE: D-27

980 American Center Bldg., 150 East Kellogg Blvd., St. Paul, Minnesota 55101


Conduit to service head, modify detail for service underground.
Electrical outlet (TYPICAL) in 1½" space. DO NOT penetrate vapor barrier
(3) #3 R.H.W.
Caulk & seal opening in rim joist
Non-hardening sealant all around.
Repair vapor barrier penetration w/ caulk all around (non-hardening)
ELEC. & PLBG CHASE. See wall section.
R-7 INSUL
Finished basement (insul.) wall.
Surface mounted main panel @ basement wall. or recessed in stud wall.

SERVICE ENTRANCE

SCALE: 1 1/2" = 1'-0"

MINNESOTA ENERGY AGENCY - SUPER INSULATED HOME DEMONSTRATION PROJECT
DRAWING TITLE: ELECTRIC SERVICE ENTRANCE
DRAWING NUMBER SI-9
DRAWN BY: KWH DATED: 3/1/82 SCALE: 1½" = 1'-0"
REFERENCE: D-26
980 American Center Bldg., 150 East Kellogg Blvd., St. Paul, Minnesota 55101

III - 35
FIGURE III - 29

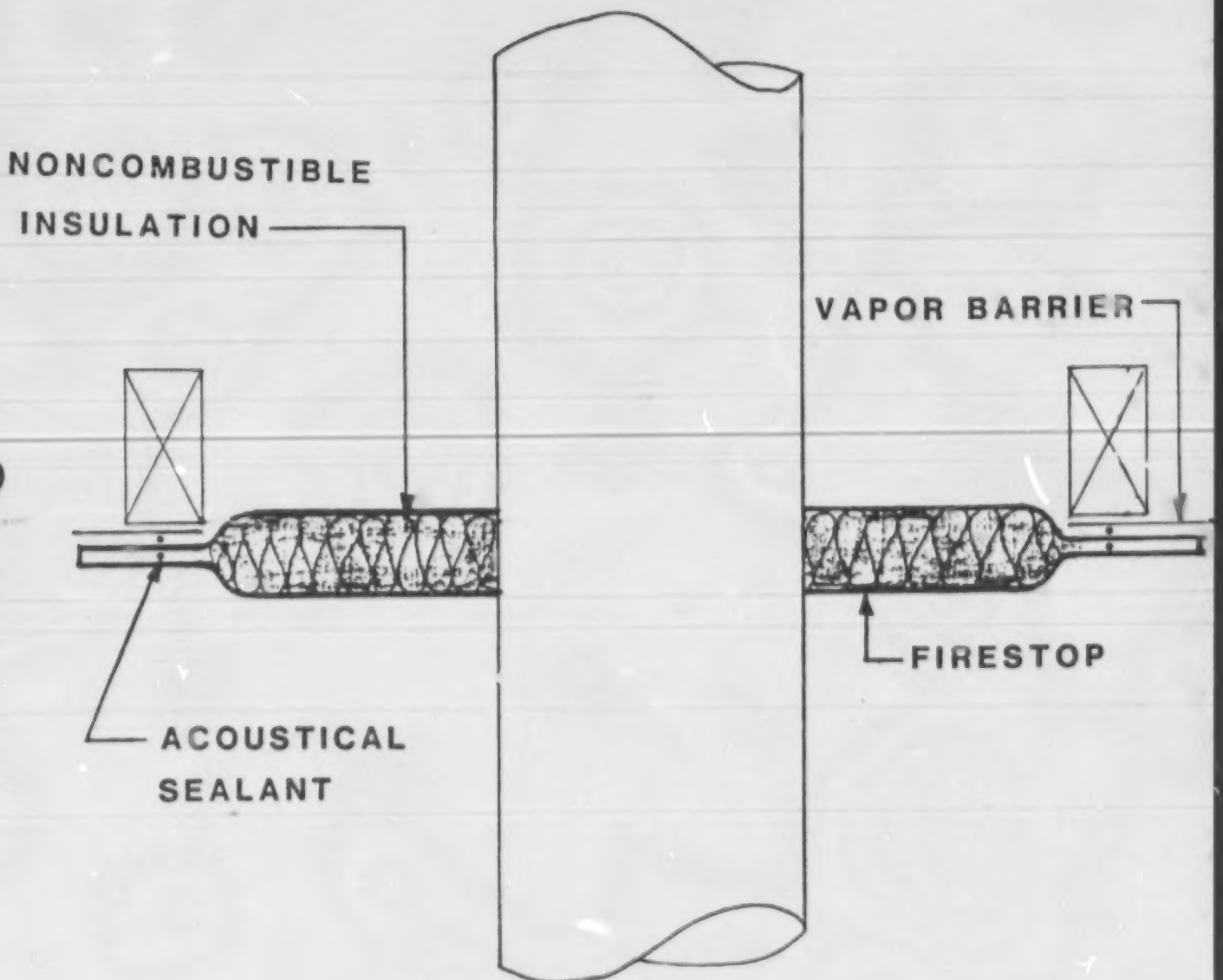


FIGURE III - 30

CHIMNEY INSTALLATION DETAIL

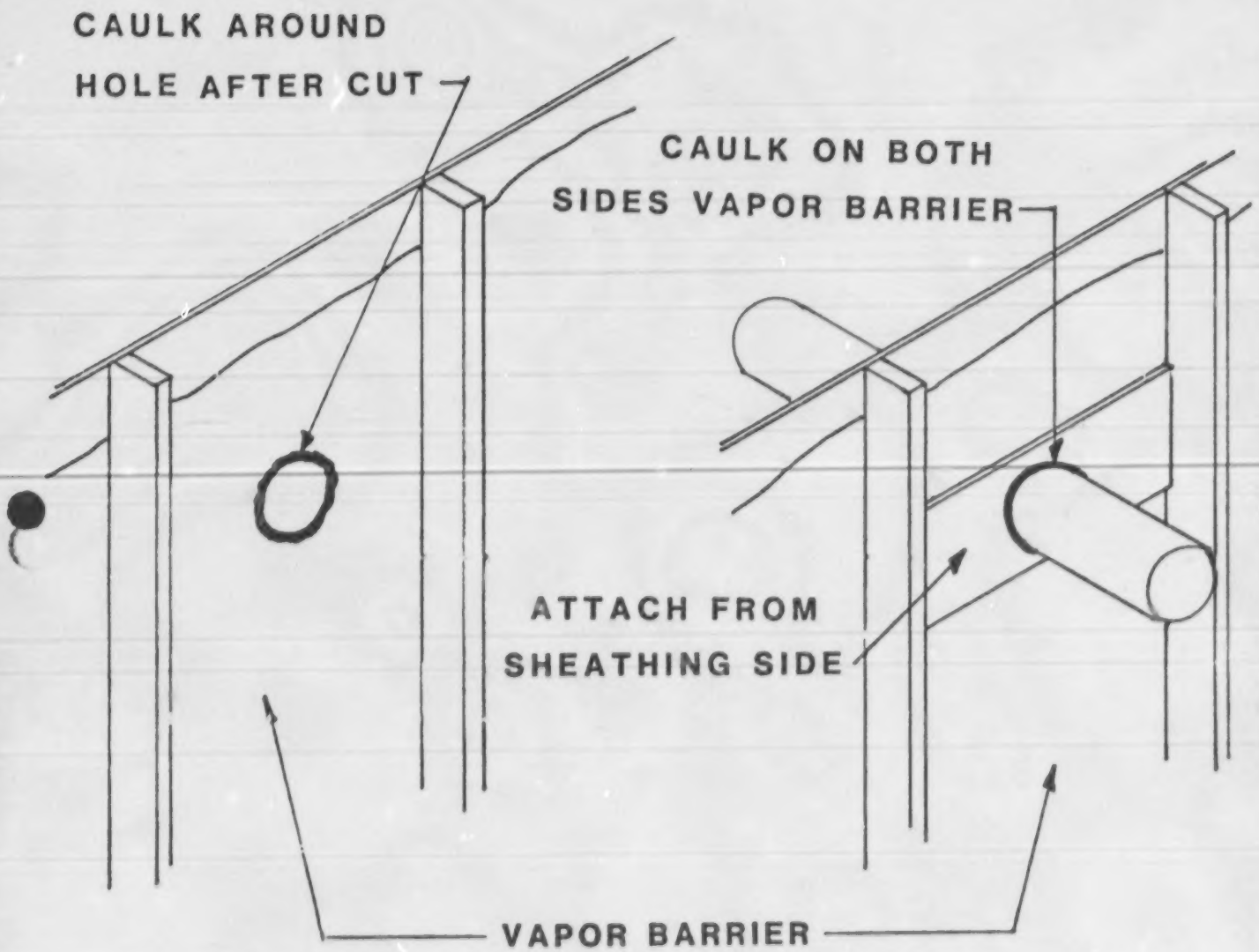


FIGURE III - 31

SEALING VAPOR BARRIER PENETRATION VENT PIPES, ETC.

III - 37a

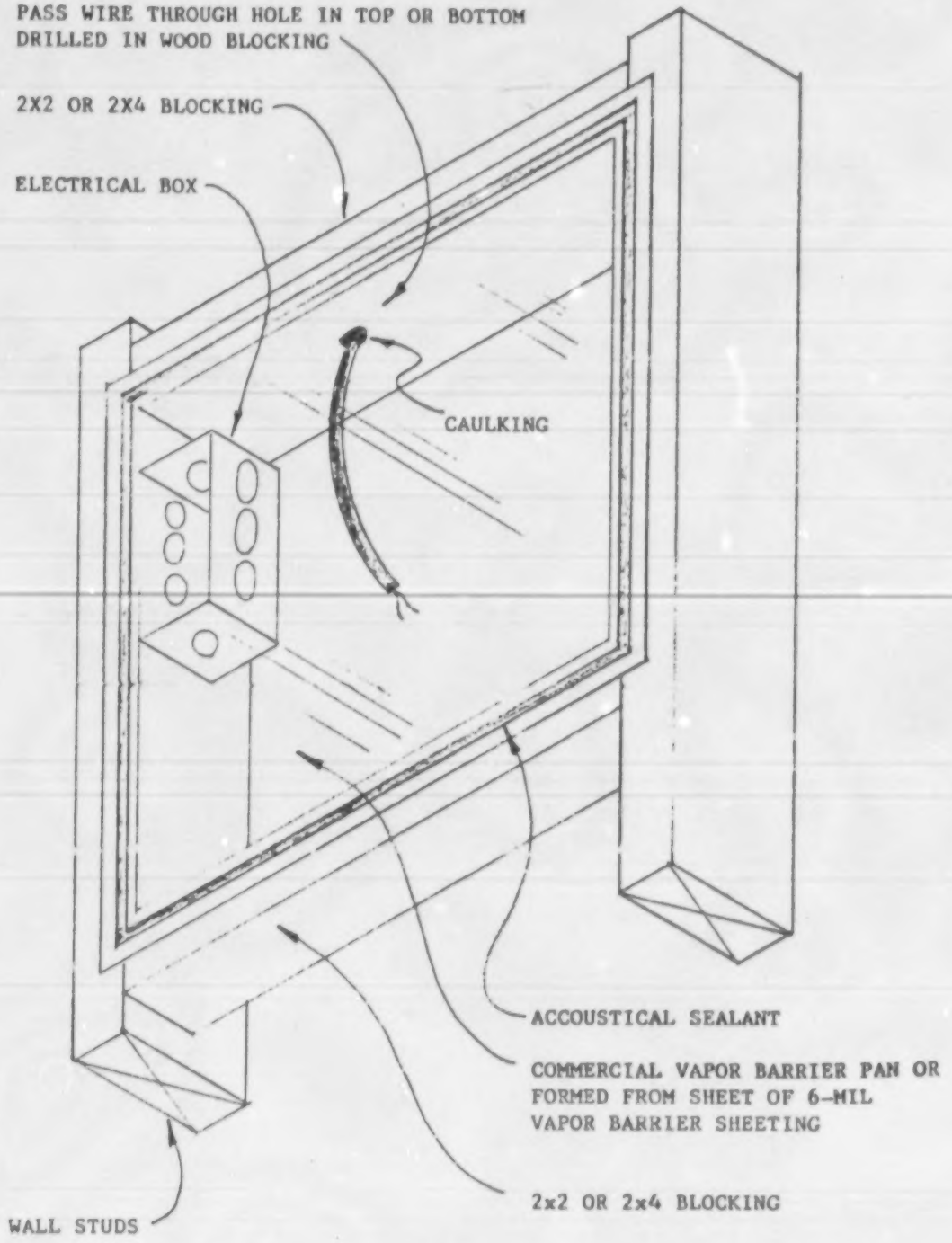

PASS WIRE THROUGH HOLE IN TOP OR BOTTOM DRILLED IN WOOD BLOCKING
2X2 OR 2X4 BLOCKING
ELECTRICAL BOX
CAULKING
ACCOUSTICAL SEALANT
COMMERCIAL VAPOR BARRIER PAN OR FORMED FROM SHEET OF 6-MIL VAPOR BARRIER SHEETING
2x2 OR 2x4 BLOCKING
WALL STUDS

FIGURE III - 32

MINNESOTA ENERGY AGENCY - SUPER INSULATED HOME DEMONSTRATION PROJECT

DRAWING TITLE: VAPOR BARRIER/ELEC. BOX DRAWING NUMBER SI-I

DRAWN BY: TG/KH DATED: 3/14/82 SCALE: NONE REFERENCE: D-1

980 American Center Bldg., 150 East 6th Place, St. Paul, Minnesota 55101

B. FOAM SEALANTS

Foam sealants are frequently utilized in superinsulated homes. Even with a correctly applied vapor barrier, infiltration can still enter through external openings like utility runs (electrical, plumbing, telephone, etc.) and especially gaps concealed by the window molding and door frames. If the vapor barrier is not applied in these areas, the gaps can account for 40 percent of the heat loss attributable to infiltration. Rather than using fiberglass and caulk to fill and seal these gaps or cracks, a foam sealant can be a valuable supplement to the vapor barrier. Typically, application is similiar to that of a caulk, except the foam sealant expands two to three times the original size as it cures. Thus, careful application requires allowing for expansion in any gaps or cracks being framed. It is not necessary to completely fill areas around windows or doors, for example. The foam is used to seal, it's insulating value is secondary. If the cured foam expands beyond the cavity being filled, any excess can be easily trimmed with a sharp knife or simple sanding.

If the vapor barrier and/or foam sealant are correctly applied, the house air change per hour (ACH) will be reduced to 0.1 (ACH). This constrasts with current construction practice, where typical ACH is 1.0.

C. AIR-TO-AIR HEAT EXCHANGER

Air-to-air heat, exchangers* are frequently needed in superinsulated homes due to the dramatic reduction in infilitration. The immediately

* Heat Exchangers are covered in detail in Section X.

noticed consequence of the super-sealed construction is moisture build-up[1] and the potential for indoor air pollutants; like bath or kitchen odors, smoking and others.**

In superinsulated homes, these problems are avoided by directly venting all stale, inside air from the bath, dryer, etc. through the air-to-air heat exchanger. The heat exchanger has two small fans which can be adjusted to completely change the indoor air; typically, once every two hours. It can be tied to an existing furnace duct system, or (if the house uses baseboard electric) it can have its own independent duct system.

The heat exchanger serves three functions: (1) heat recovery; (2) de-humidification; and (3) enhanced air quality, which are described later.

** Indoor Air Quality is covered in detail in Section IX.

1 Daily moisture production for a family of four typically amounts to 6+ gallons each day.

people breathing	12 pints	clothes washing	5 pints
dishwashing	1-2 pints	clothes drying	26 pints
cooking	4 pints	baths	2 pints

D. BIBLIOGRAPHY

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Department of Mechanical Engineering (University of Saskatchewan), Energy Efficient Housing: A Prairie Approach, Saskatchewan Mineral Resources: Office of Energy Conservation, (October, 1980) 31 pages.

Brian Marshall and Robert Argue, The Super-Insulated Retrofit Book, Renewable Energy in Canada, Toronto, (October, 1981).

Michael G. Scott, Energy Efficient House Design and Construction Techniques, MASEC-R-80-1136 (September, 1980).

Michael G. Scott, Superinsulation Slide Show, MASEC-R-81-082, (June, 1981).

Michael G. Scott, Summary of the North Star Home, MASEC-R-81-086, (September, 1981).

In addition, a number of wall section graphics were from blueprints for several superinsulated homes.

Don E. Kraft (Ripon, Wisconsin), North Star House. Swanco Construction, Brooklyn Park, MN.
Richard Hand (Anoka, MN), Hand House, Hand Construction, Anoka, MN.
James Martin (Minneapolis, MN), Solar Saltbox, P & M Construction, Northfield, MN.

ENERGY CONSERVATION SUPPLEMENT TO BUILDING PERMIT APPLICATION
PLANNING AND INSPECTION DEPARTMENT

SAMPLE FORM

This supplement is provided to assist the applicant in computing EXTERIOR ENVELOPE AVERAGE "U" FACTOR INFORMATION. This information is required so the BUILDING OFFICIAL can determine that submitted plans comply with the ENERGY CONSERVATION DESIGN CRITERIA of the STATE BUILDING CODE (Section 6000). It is the APPLICANT'S responsibility to accurately compute the data; reflect the proper DESIGN CRITERIA in the plans; submit product specifications, if needed to support the "R" and "U" factors used; and to assure construction is per approved plans.

JOB LOCATION _____

OWNER(S) _____ PHONE _____

CONTRACTOR _____ PHONE _____

A. Determine the Total Exposed Wall Area as follows:

1. Total wall window area _____
2. Total door area _____
3. Total sliding glass door area _____
4. Total Fireplace wall area _____
5. Total wall framing area (average10%) _____
6. Total net wall area above floor _____
7. Total rim joist area _____

Subtotal: Total exposed wall area above floor _____

8. Total foundation window area _____
9. Total net foundation area above grade _____

Subtotal: Total exposed foundation area _____

GRAND TOTAL EXPOSED WALL AREA _____

B. Multiply the GRAND TOTAL EXPOSED WALL AREA x .19 = Item I. [ ]

C. Determine the Total Exposed Roof/Ceiling Area as follows:

10. Total skylight area _____
11. Total roof/ceiling framing area _____
12. Total net insulated roof/ceiling area _____

GRAND TOTAL EXPOSED ROOF/CEILING AREA _____

D. Multiply the GRAND TOTAL EXPOSED ROOF/CEILING AREA X .04 = Item II. [ ]

50

E. Determine the "U" value of each segment (1-9) and multiply by the area as follows:

1. _____ X "U" _____ = _____
2. _____ X "U" _____ = _____
3. _____ X "U" _____ = _____
4. _____ X "U" _____ = _____
5. _____ X "U" _____ = _____
6. _____ X "U" _____ = _____
7. _____ X "U" _____ = _____
8. _____ X "U" _____ = _____
9. _____ X "U" _____ = _____

ADD 1-9 FOR TOTAL WALL SEGMENTS = Item III. [ ]

F. Determine the "U" value of each segment (10-12) and multiply the area as follows:

10. _____ X "U" _____ = _____
11. _____ X "U" _____ = _____
12. _____ X "U" _____ = _____

ADD 10-12 FOR TOTAL ROOF/CEILING SEGMENTS = Item IV [ ]

G. If Item No. III is the same as, or less than Item No. I, you have not met the intent of State Building Code 6006(c)2.

H. If Item No. IV is the same as, or less than Item No. II, you have met the intent of State Building Code 6006(c)1.

I. Add Item No. I._____ + Item No. II _____ = _____

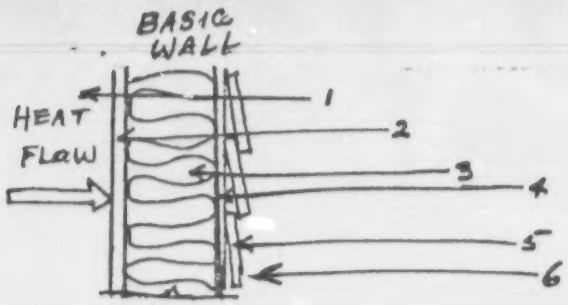
J. Add Item No. III_____ + Item No. IV _____ = _____

K. If the sum of Items III and IV are less than Items I and II, you have met the intent of the code for total envelope system.

The undersigned, as applicant for a Building Permit, hereby affirms the above information has been prepared and submitted by himself or under his direction, hereby acknowledges the information to be correct and accurate; and hereby presents the information with required plans in support of the Building Permit Application.

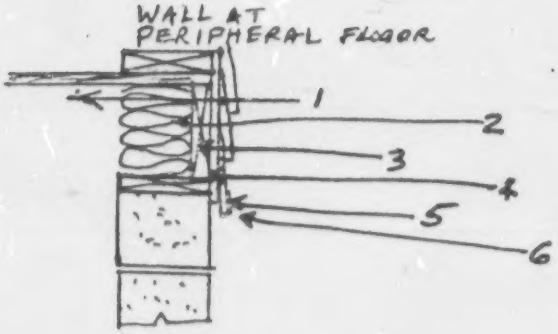
_____
Signature

_____
Date



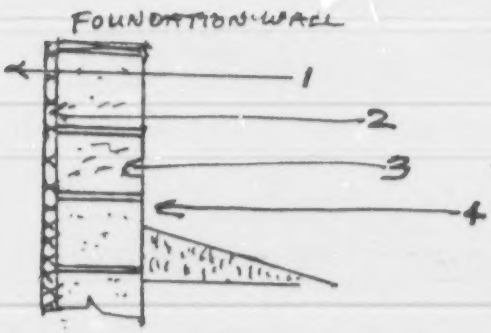
1. Interior Air Film = _____
2. Wall Finish = _____
3. Insulation = _____
4. Sheathing = _____
5. Siding = _____
6. Exterior air film.... _____

Total R = _____ U= _____



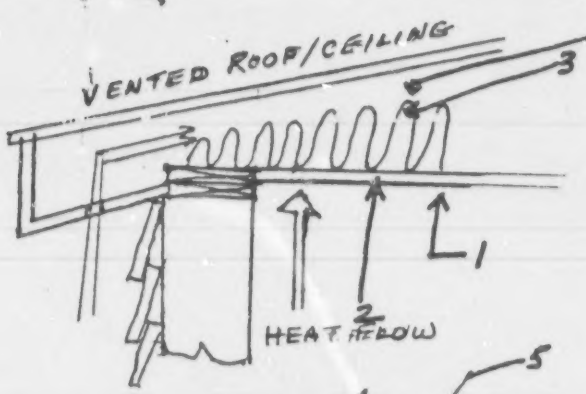
1. Interior air film.... 0.68
2. Insulation = _____
3. Rim joists _____
4. Sheathing _____
5. Siding _____
6. Exterior air film.... 0.17

Total R = _____ U= _____



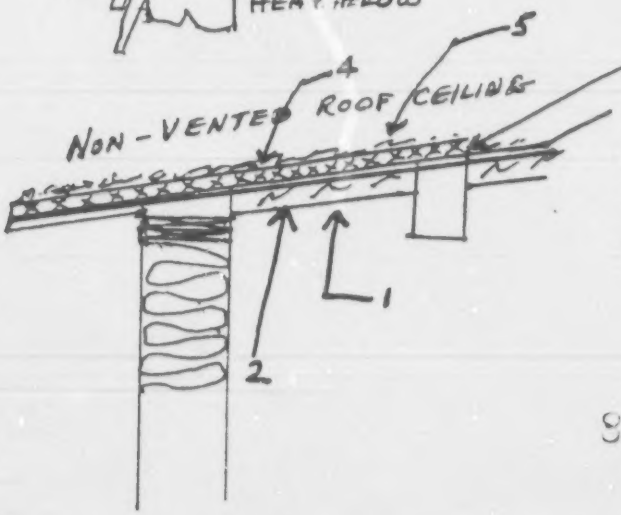
1. Interior air film.... 0.68
2. Insulation = _____
3. Fnd. Walls = _____
4. Exterior air film..... 0.17

Total R = _____ U= _____



1. Interior air film..... 0.61
2. Ceiling finish = _____
3. Insulation = _____
4. Exterior air film .... 0.61 (still)

Total R = _____ U= _____



1. Inside air film..... 0.61
2. Decking = _____
3. Insulation _____
4. Roofing _____
5. Outside air film 0.17

Total R = _____ U= _____

(R = 1/U) (U= 1/R)

GUIDELINE TO (R) FACTORS OF TYPICALLY USED PRODUCTS FROM ASHRAE MANUAL

	(R)
Interior Air Film (Walls)	0.68
Exterior Air Film (Walls)	0.17
Interior Air Film (Vented Ceiling)	0.61
Exterior Air Film (Vented Ceiling)	0.61
Interior Air Film (Non-Vented)	0.61
Exterior Air Film (Non-Vented)	0.17
1/4" Plywood Panel	0.31
3/8" Plywood Panel	0.47
1/2" Fiberboard Sheathing	1.32
25/32" Fiberboard Built Rite Shg.	2.06
Aluminum Siding	0.61
w/Backer	1.82
w/Backer and Foiled	2.96
1/2 x 8 Lap siding (wood)	0.81
7/16 x 12 Hardboard Siding	0.67
Asbestos Sidings	0.21
Stucco (Brown & Finish Coat)	-
8" Concrete Block (S & G Reg.)	1.11
12" Concrete Block (S & G Reg.)	1.28
8" Light Weight	2.18
12" Light Weight	2.48

Built-up Roofing	0.33
(Add for Insulation)	-
3/8" Gypsum Boards	0.32
1/2" Gypsum Boards	0.45
5/8" Gypsum Boards	0.56
3/4" Wood Subfloor or Sheathing	0.94
1/2" Plywood Sheathing	0.62
1/2" Particle Board	0.66
Insulation - 3 1/2" Fiberglass	11.00
6" Fiberglass	19.00
6 1/2" Fiberglass	22.00
8 1/2" Fiberglass	32.00

(All other insulation materials must be verified for R-Factor)

Filled with Vermiculite:

----------	1.93
----------	3.15
----------	5.03
----------	5.82

****

	Note: (U) x area in sq. ft.
All Windows (w/storms 1" to 4" space	.56
Removal double glazing (RdG)	.55
Thermo or welded 3/16" air space	.69
1/4" air space	.65
1/2" air space	.58
(Other windows specifically tested can use better ratings)	
1 3/4 Solid core door	.46
w/storm, wood	.31
w/storm, metal	.26
Pease Steel Insl. Door (No/Gl) 7.45R	.13
Sliding Glass Door, wood	.65
metal	.715

****

Note: (R) factors & (U) factors cannot be added, they must be converted to one or the other. Formulas for conversion are U = 1/R or R = 1/U

Required (R) Factors or (U) Factors for Building Envelopes.

Exterior Walls	(R)	(U)
1 & 2 Family	5.9	.17
All Other Bldgs.	4.54	.22
Ceilings & Roofs		
1 & 2 Family	20.0	.05
All Other Bldgs.	10.0	.10

Floors (incl. crawl areas)	(R)	(U)
Floor wood	10.0	.10
concrete slab	7.5	.13

IV. WALLS

TABLE OF CONTENTS

		PAGE
A.	SINGLE WALL STRATEGIES: NEW CONSTRUCTION	2
B.	DOUBLE WALL STRATEGIES: NEW CONSTRUCTION	7
C.	SINGLE WALL STRATEGIES: RETROFIT CONSTRUCTION	15
D.	DOUBLE WALL STRATEGIES: RETROFIT CONSTRUCTION	23
E.	BIBLIOGRAPHY	29

--INTRODUCTION--

The above grade frame wall R-values of the superinsulated home are at least R-30, but many have been built with R-50+, which is consistent with the Robinson Rules-of-Thumb. There are a number of single and double wall construction strategies to build either a new or retrofit superinsulated wall. Single wall strategies add one to four inches of insulated sheathing to form a thermal break. Doublewall strategies vary by either making the exterior or interior wall the bearing wall.

A. SINGLE WALL STRATEGIES: NEW CONSTRUCTION

Many of the early superinsulated homes built in Minnesota utilized 2 x 6 or 2 x 8 wall framing with one or more inches insulated sheating.

(1) 2 x 6 stud walls, 24" on center, use 6" of fiberglass or cellulose fiber in the wall cavity with 2" or more of insulated foam sheathing to the outside obtain a R-30+ value. (Figure IV-1) Quite a number of exterior insulation systems are appearing on the market. Basically, these insulated sheathing systems are applied in layers, similiar in concept to lamination. Typically, expanded polystrene (EPS) insulation board, is bonded to the exterior of a building. To reduce cracking from thermal stress, fiberglass is usually an element of the system -- either in the form of a mesh embeded in an adhesive, or as fibers mixed into the surface coating. To overcome problems in attaching traditional exterior coverings or siding, a number of alternative exterior finish coats for the extra thick layers of insulated sheathing have been developed. These exterior finish coats range from acrylic and portland cement mixtures to a total synthetic, which resembles a stucco.

(2) 2 x 8 stud walls, 24" on center, use 8" batts of fiberglass in the wall cavity with 1" thick sheathing serving as the thermal break on the exterior wall. The only difference between superinsulated and conventional walls is the thickness. The window openings can also serve as window seats. Also, notice no spot is left uninsulated, not even the box headers or rim joists. (Figure IV-2)

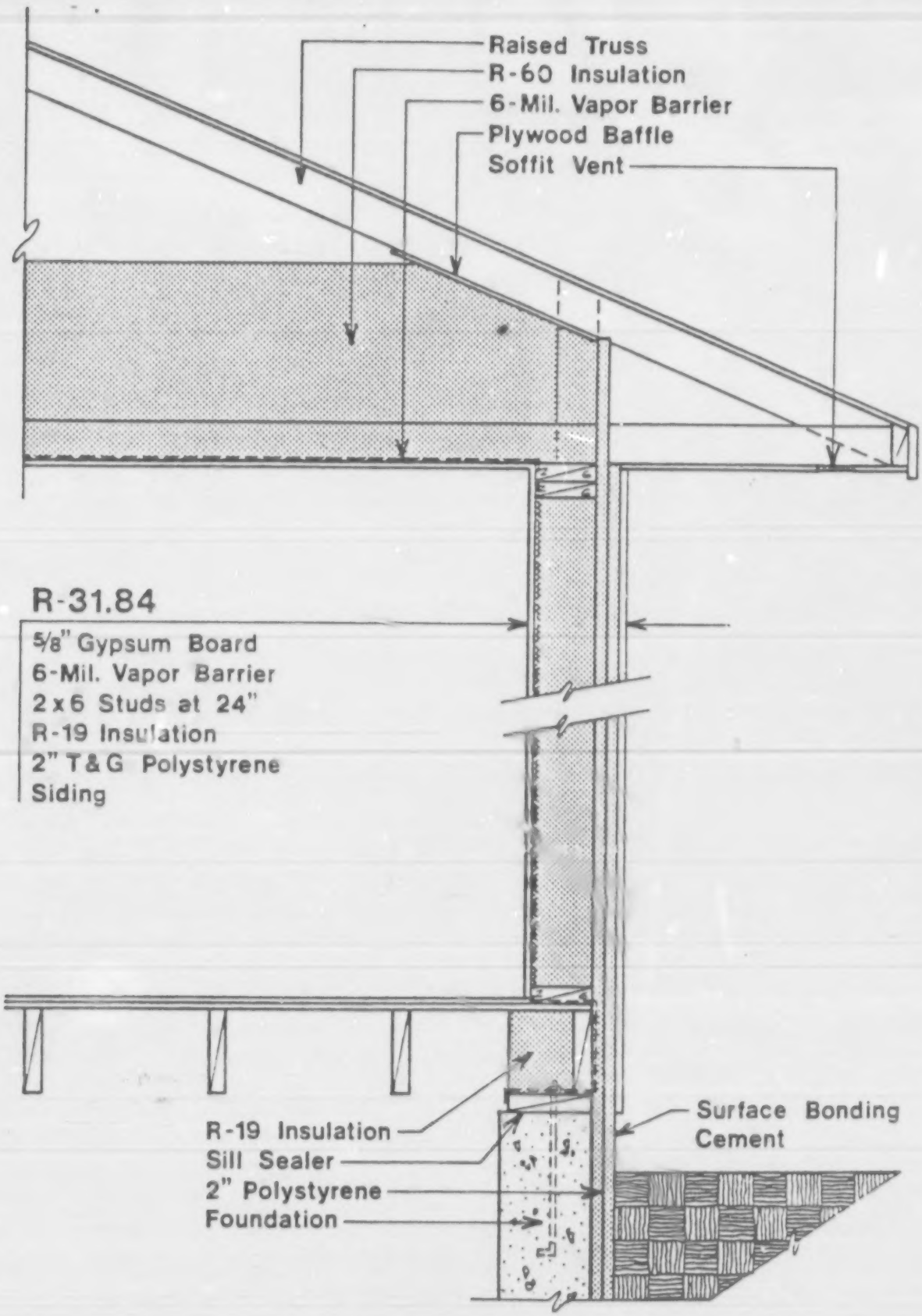


FIGURE IV - 1

97

2x6 WALL FRAMING

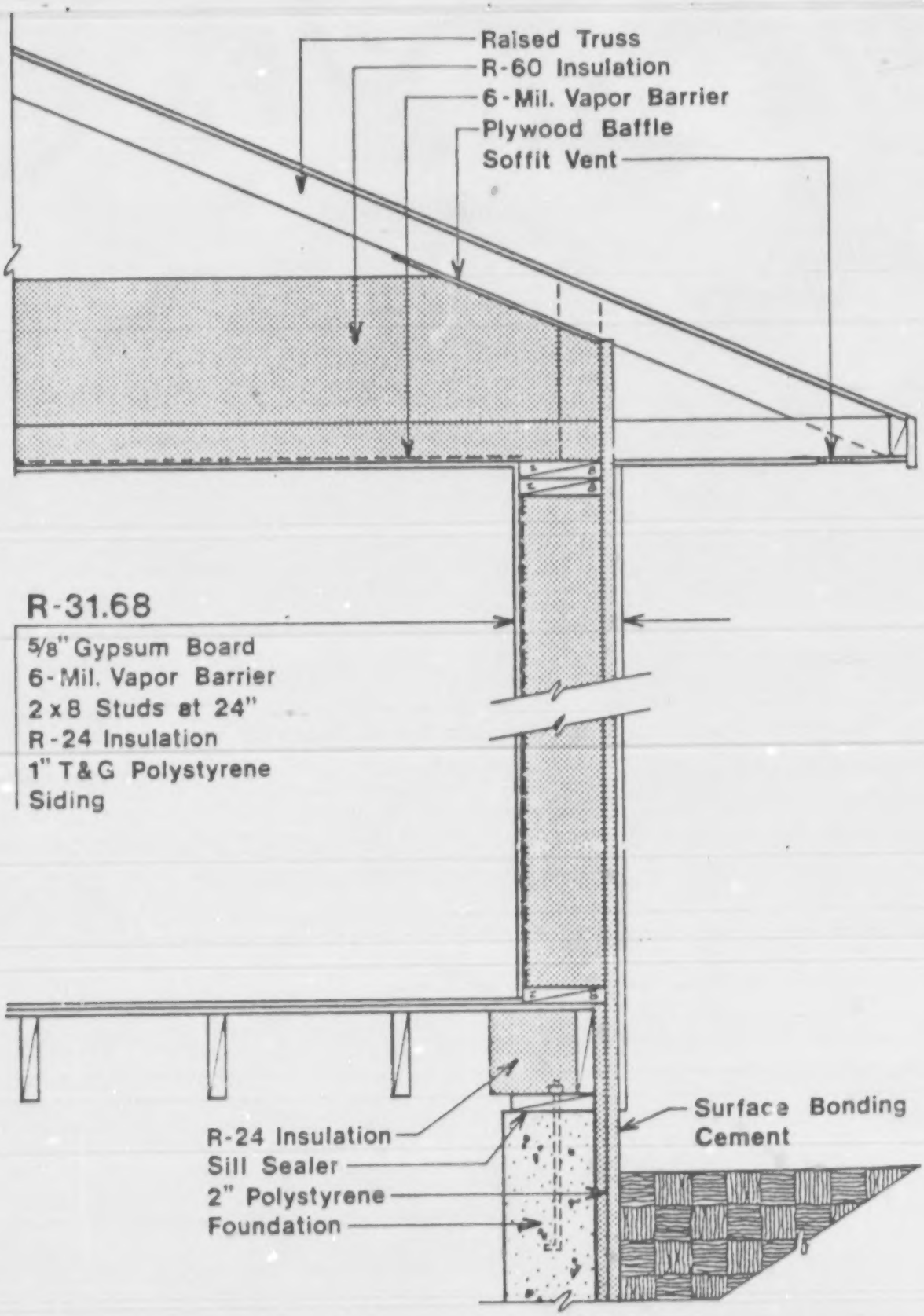


FIGURE IV - 2

2x8 WALL FRAMING

SUPERINSULATION LTD.

The major drawback of building a house using single sticks of wood (either 2 x 6 or 2 x 8) means the vapor barrier will be penetrated for utility runs (e.g., electrical boxes). In Sweden, Canada, and Alaska, the need to penetrate the vapor barrier is regularly avoided by utilizing a cross hatch technique.

(3) Alaskandinavian or crosshatch technique (Figure IV-3) has several advantages. First, it significantly reduces heat-flow through the framing members. Second, it is easy to build and does not cost a great deal more than conventional framing.

Generally, the Alaskandiavian technique requires 2 x 2's nailed perpendicular to the studs and sometimes ceiling joists. The 2 x 2's are sometimes even attached above the bottom plate and below the top plate to prevent conduction through the framing members (this may cause a problem when installing the base and shoe). Also, the corner framing must be modified so there is something to nail the 2 x 2's onto.

The cavity created by the 2 x 2's , allows the common exterior utility runs (electricity, telephone, TV wire, etc.) to go on the warm side of the vapor barrier. (No vapor barrier penetrations!) Frequently, some plumbing vent pipes are run through the cavity, although the interior walls are the best place for plumbing runs, to avoid vapor barrier problems. Some builders have then applied sheetrock with a reflective foil backing to finish the wall. Other builders insulate the cavity with fiberglass. All techniques produce good results.

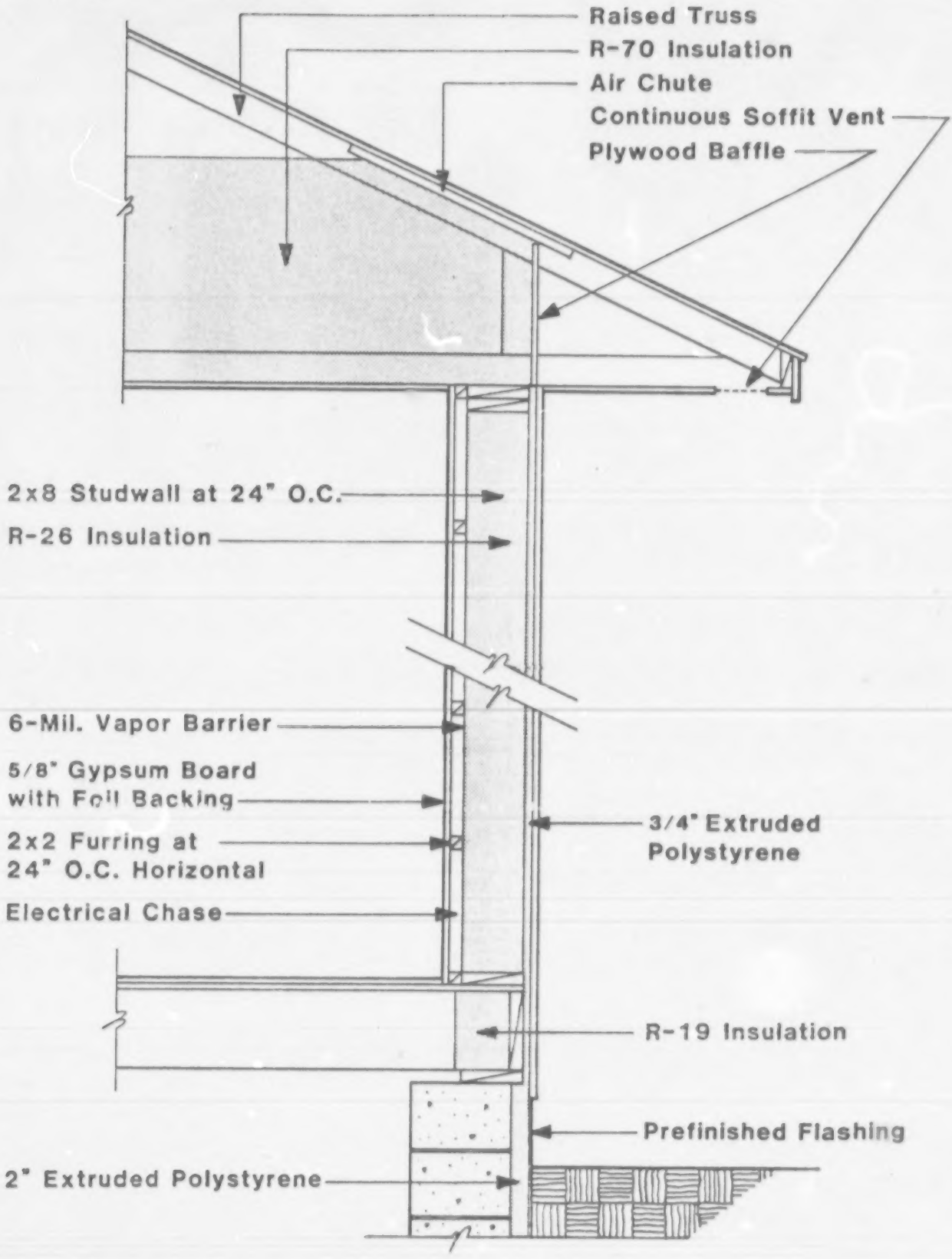


FIGURE IV - 3

ALASKANDINAVIAN WALL

Single stud superinsulated wall construction is not significantly different than conventional building practices with two major exceptions. (a) Several common siding products are not compatible with the insulated sheathing. (b) Condensation problems can occur in the joist areas, or box headers, especially in homes with full basements or more than one level.

(a) Certain types of siding (redwood, masonite, etc.) can warp when applied over insulated sheathing (especially in thicknesses greater than 2 inches) sometimes even popping the nails. The builder should avoid those types of siding where dampness can form between the insulated sheathing and siding. Also, some siding products have different thermal co-efficients of expansion than the insulated sheathing, which will also cause warping.

(b) Two options exist to avoid condensation problems where it is impractical to run a vapor barrier between floors. A plastic sheet can be hung between the joists. However, this is very difficult where the joists are perpendicular with the wall. A more practical solution (Figure IV-4 and IV-5) is the use of foil-backed insulation board. In either case, the vapor barrier must be foamed or caulked or taped to form an air-tight seal.

B. DOUBLE WALL STRATEGIES: NEW CONSTRUCTION

To construct walls with R-values greater than 35, requires the use of double walls. While there are numerous variations, two methods primarily used to constuct the double walls can be classified by the use of the vapor barrier.

(1) The U.S. double wall uses two 2 x 4 walls 24" on center with the studs offset. The total wall cavity is generally 8 to 14 inches thick (Figure IV - 6). The exterior wall is first erected and serves as the bearing wall. The roof put on, and the house closed in. The interior wall can be erected at a later time. This technique provides room for

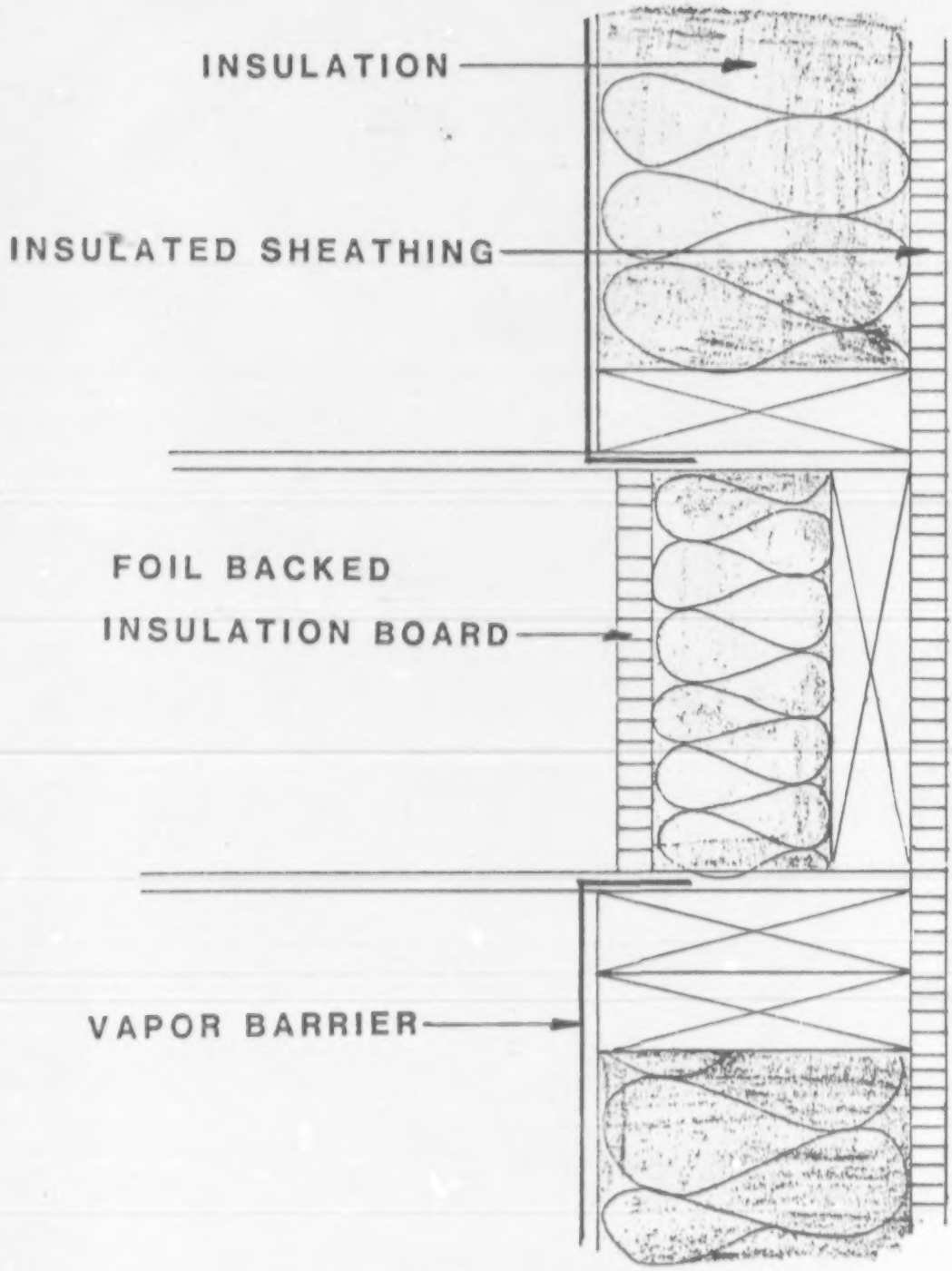


FIGURE IV - 4

VAPOR BARRIER TREATMENT AT HEADER

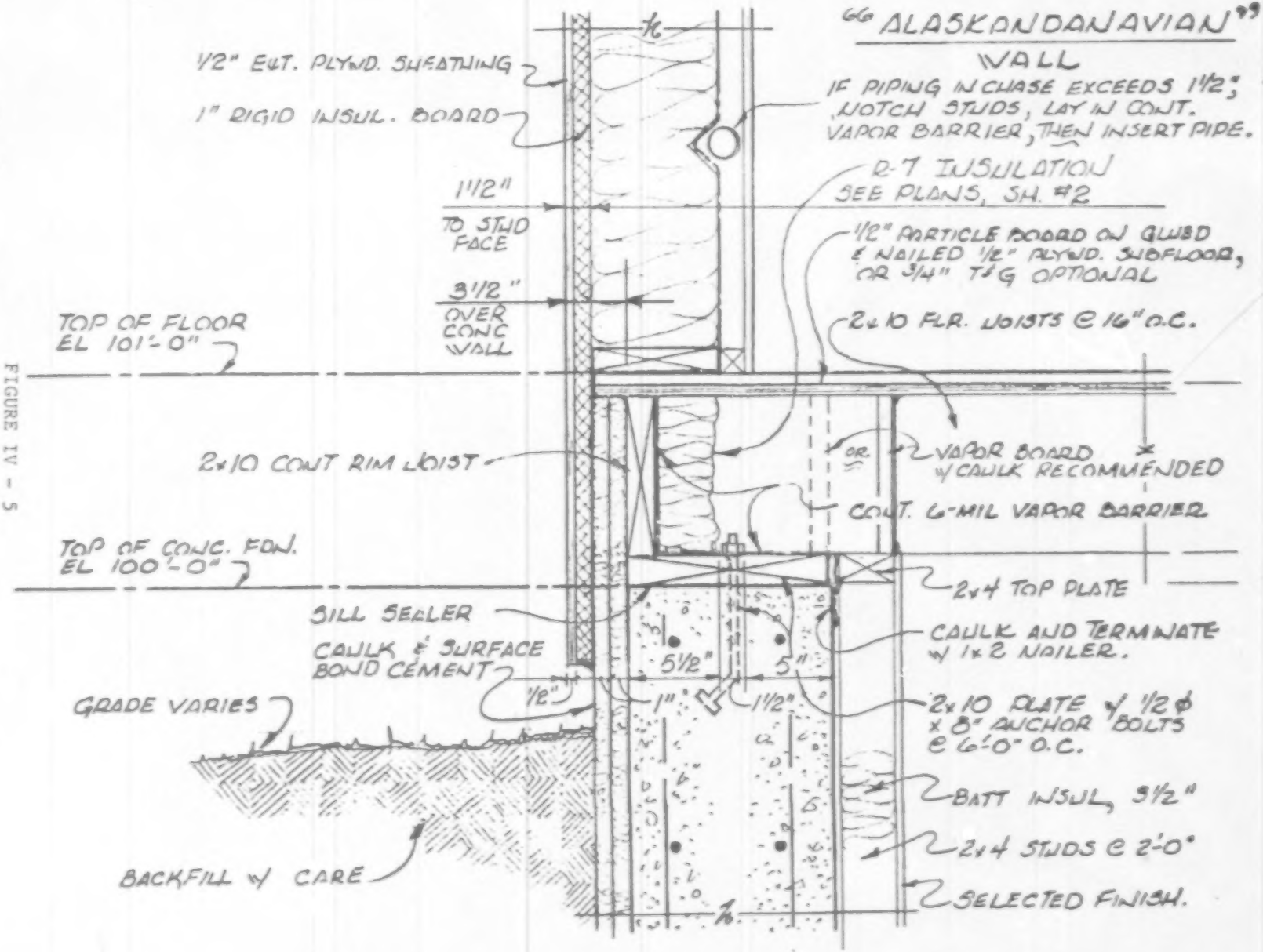

"ALASKANDANAVIAN" WALL
1/2" EXT. PLYWD. SHEATHING
1" RIGID INSUL. BOARD
IF PIPING IN CHASE EXCEEDS 1 1/2"; NOTCH STUDS, LAY IN CONT. VAPOR BARRIER, THEN INSERT PIPE.
R-7 INSULATION SEE PLANS, SH. #2
1 1/2" TO STUD FACE
3 1/2" OVER CONC WALL
1/2" PARTICLE BOARD ON GLUED & NAILED 1/2" PLYWD. SUBFLOOR, OR 3/4" T&G OPTIONAL
TOP OF FLOOR EL 101'-0"
2x10 FLR. JOISTS @ 16" O.C.
2x10 CONT RIM JOIST
OR
VAPOR BOARD W/ CAULK RECOMMENDED
CONT. 6-MIL VAPOR BARRIER
TOP OF CONC. FDN. EL 100'-0"
2x4 TOP PLATE
SILL SEALER
CAULK & SURFACE BOND CEMENT
CAULK AND TERMINATE W/ 1x2 NAILER.
5 1/2"
5"
1/2"
1"
1 1/2"
GRADE VARIES
2x10 PLATE W/ 1/2 ø x 8" ANCHOR BOLTS @ 6'-0" O.C.
BATT INSUL, 3 1/2"
2x4 STUDS @ 2'-0"
SELECTED FINISH.
BACKFILL W/ CARE

FIGURE IV - 5

IV - 9

MINNESOTA ENERGY AGENCY — SUPER INSULATED HOME DEMONSTRATION PROJECT

DRAWING TITLE: RIM JOIST DETAIL

DRAWING NUMBER SI-21

DRAWN BY: Kmb

DATED: 3/1/82

SCALE: 1 1/2" = 1'-0"

REFERENCE: D-28

980 American Center Bldg., 150 East Kellogg Blvd., St. Paul, Minnesota 55101

93

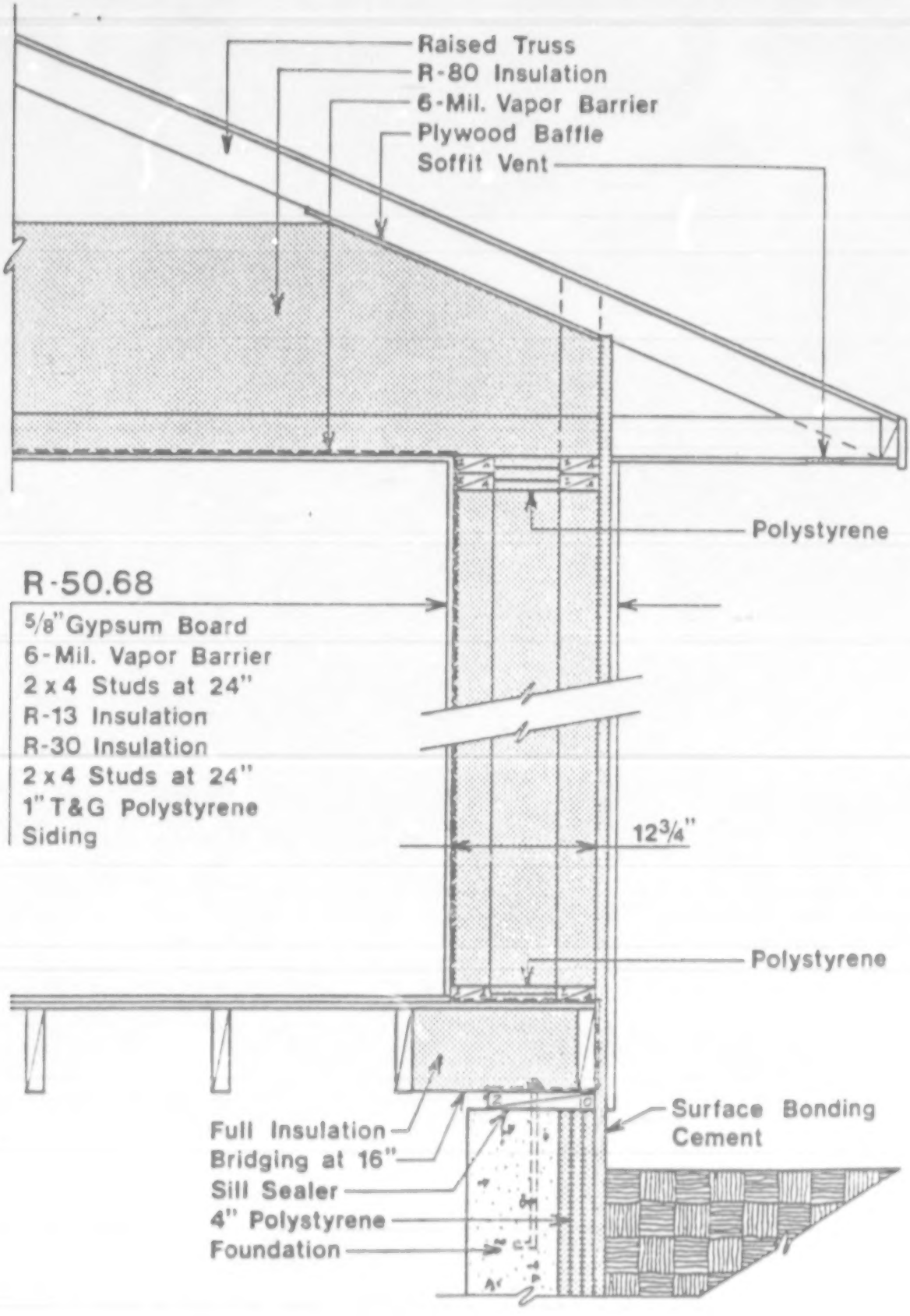


FIGURE IV - 6

91

DOUBLE 2x4 WALL FRAMING

SUPERINSULATION LTD.

lots of insulation.

However, the U.S. double creates two vapor barrier problems similiar to single wall construction strategies. The vapor barrier penetrations occur with the vapor barrier on the warm side of the interstud wall. Several corrective strategies were described in Section II. Also, several corrective measures have been suggested for vapor barrier placement between levels in rim joist areas (Figure IV-7). The Canadian double wall construction strategy offers a solution to both vapor barrier problems.

(2) Canadian double wall (Figure IV-8 and IV-9) technique differs in two important ways. First, the entire wall assembly is done at one time and tilted up into place. The outer stud wall is built on top of the interior wall. Temporary spacer blocks are used to nail the two walls together, utilizing plywood plates on top and bottom. The interior wall becomes the structure wall. When the assembly is complete, the wall is tilted up into place.

The second difference, is the method of using the vapor barrier. The Canadians place the 6 mil vapor barrier to the inside surface of the inner wall to protect the vapor barrier from penetrations by utility (e.g., electical, telephone, plumbing, etc.) runs. (A dew point in the wall will not be reached as long as twice the insulation is placed to the cold side or outside of the vapor barrier.) To fasten the vapor barrier, the Canadians prefer the use of an acoustical sealant and then staple through the sealant. The objective is always to minimize the potential for air infiltration paths.

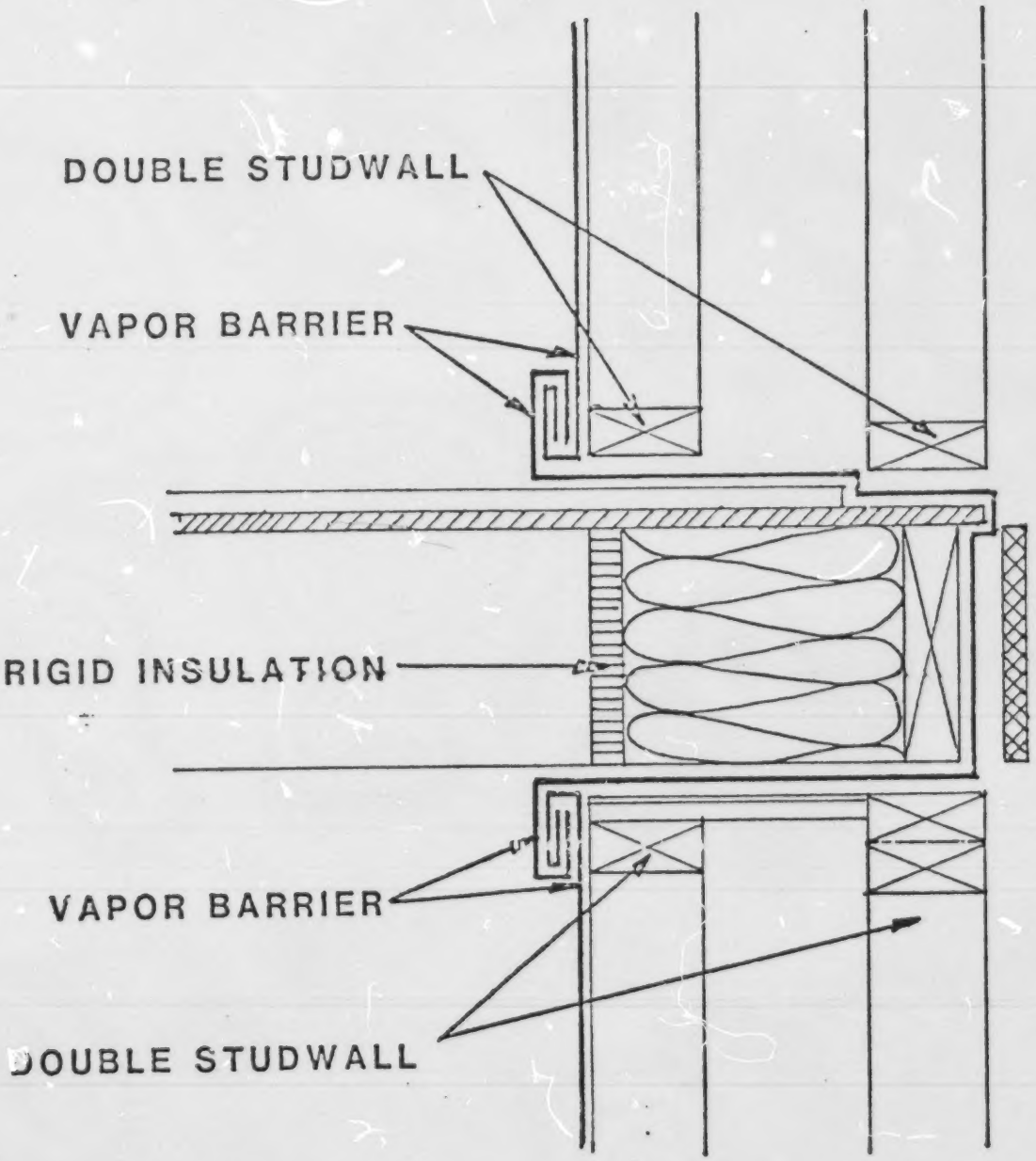


FIGURE IV - 7

VAPOR BARRIER AT WALL AND FLOOR

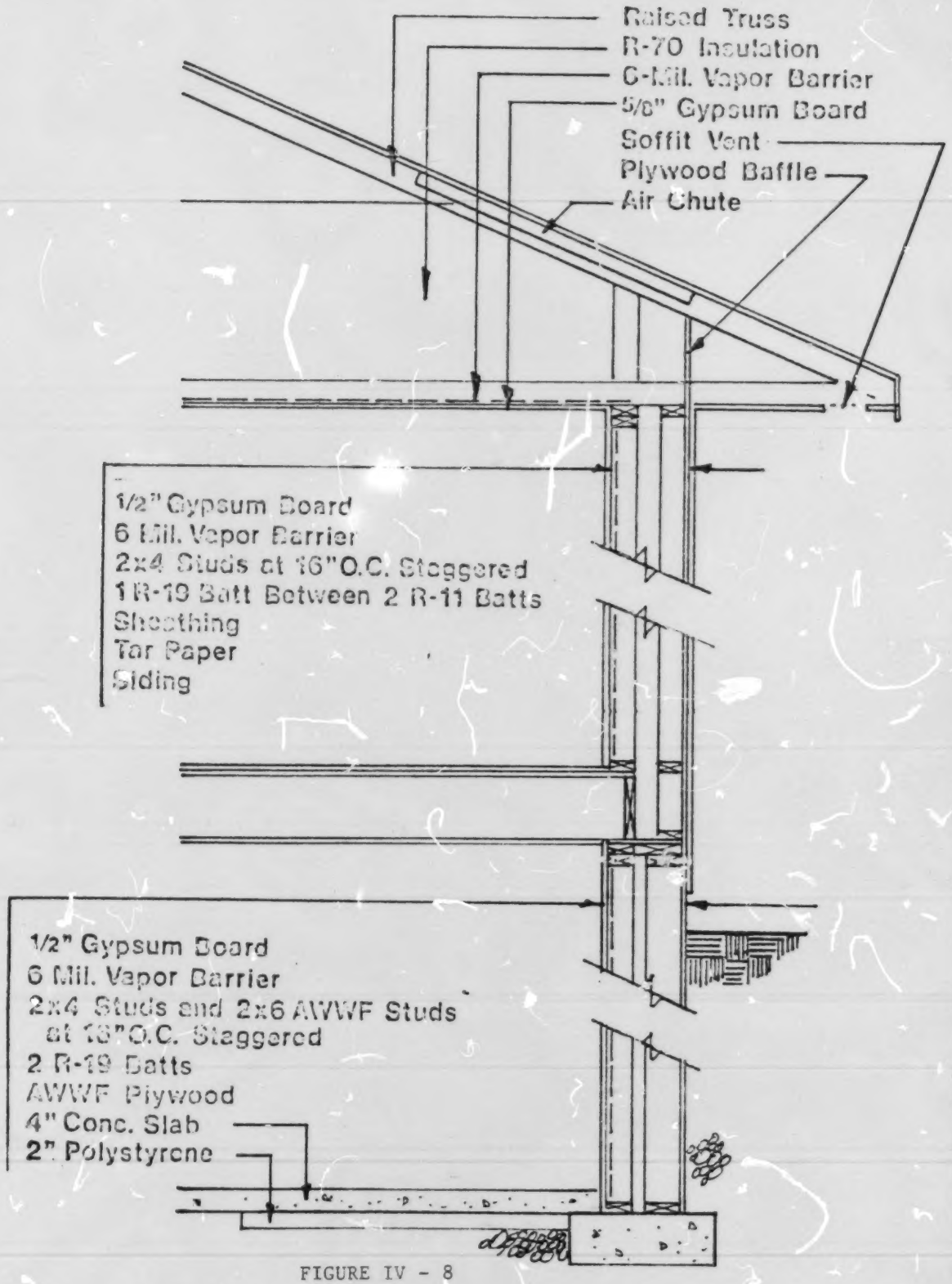


FIGURE IV - 8

CANADIAN WALL W/ WOOD FOUNDATION

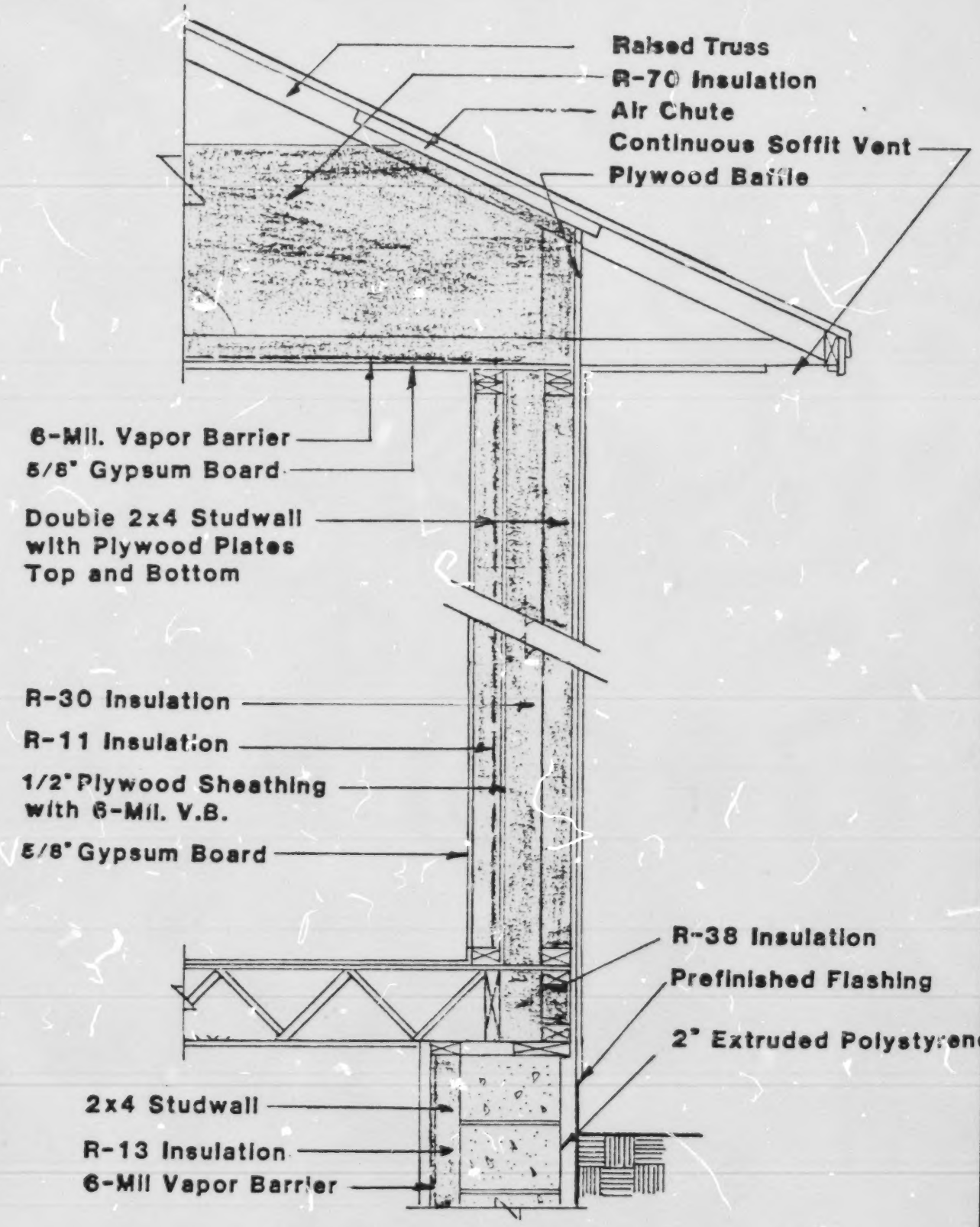


FIGURE IV - 9

CANADIAN DOUBLE WALL

The wall sections depicted in Figures IV-8 and IV-9, show the vapor barrier is continuous between floors, walls, and ceilings. Remember, the objective is to make the house as "air-tight" as possible. Figure IV-10, shows vapor barrier details at outside corners. These are only some of the construction techniques available in new construction super-insulated walls. Figure IV-11 shows another alternative used by a Massachusetts builder -- Gene Ledger. The wall framing method selected depends upon the construction strategy of other house components, materials availability and costs, labor costs and builder preferences.

C. SINGLE WALL STRATEGIES: RETROFIT CONSTRUCTION*

A number of older homes in Canada and the North Central states have been renovated and remodeled to superinsulation specifications. The super-insulated retrofit, as all major remodeling projects, requires extensive (frequently professional) planning in selecting which building strategy is best suited to the existing home. For example, before beefing up an existing wall, some rigorous engineering analysis should be performed to determine whether the existing walls, floors and foundations can support the extra weight.

The homeowner is faced with a number of potential options. Decisions will have to be made based on cost-effectiveness. In retrofit applications, caulking and weatherstripping are almost always cost effective. Building new interior or exterior walls cannot be economically feasible unless incorporated into an overall renovation. Although exterior or interior

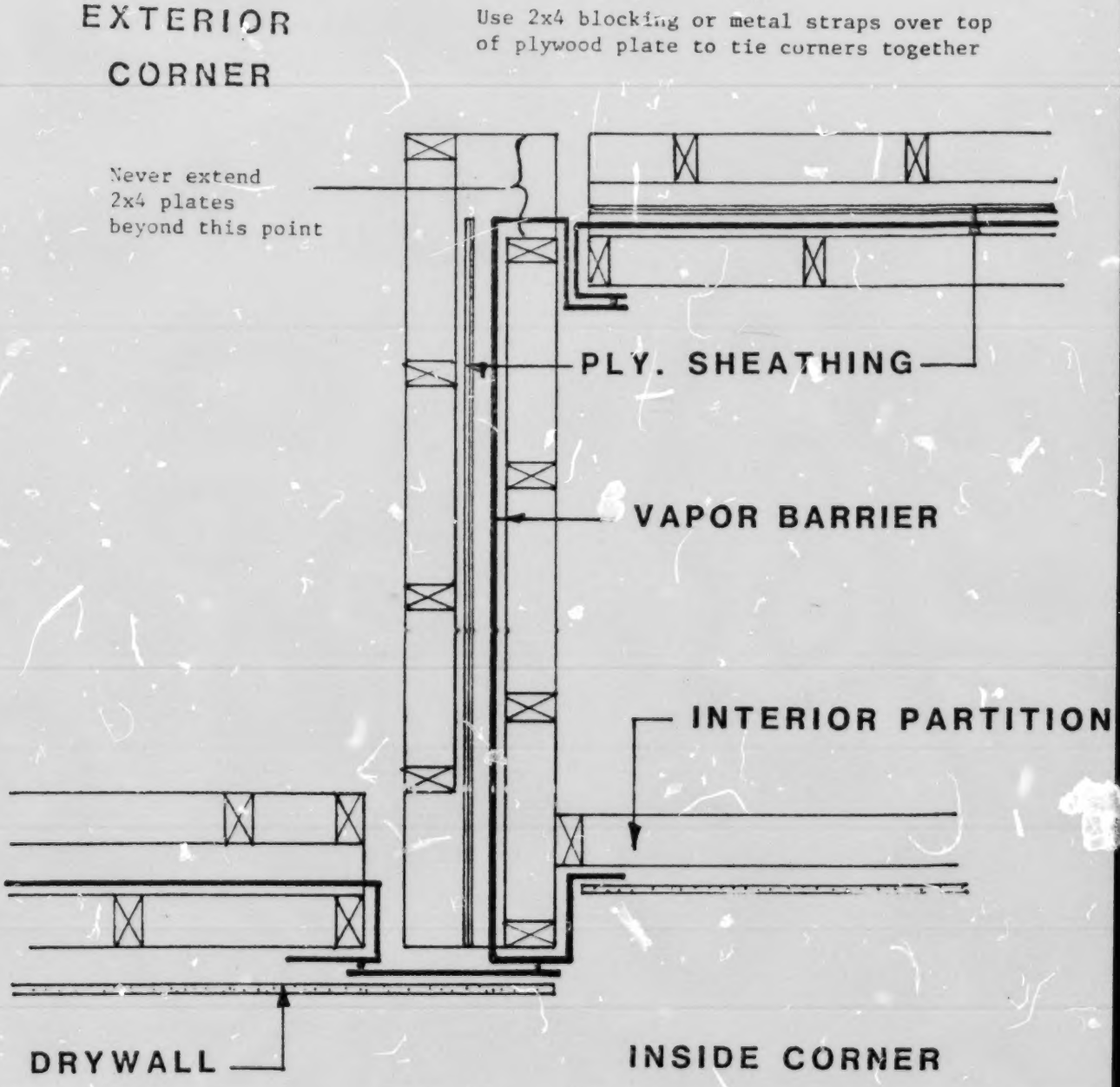


FIGURE IV - 10

CANADIAN WALL DETAIL

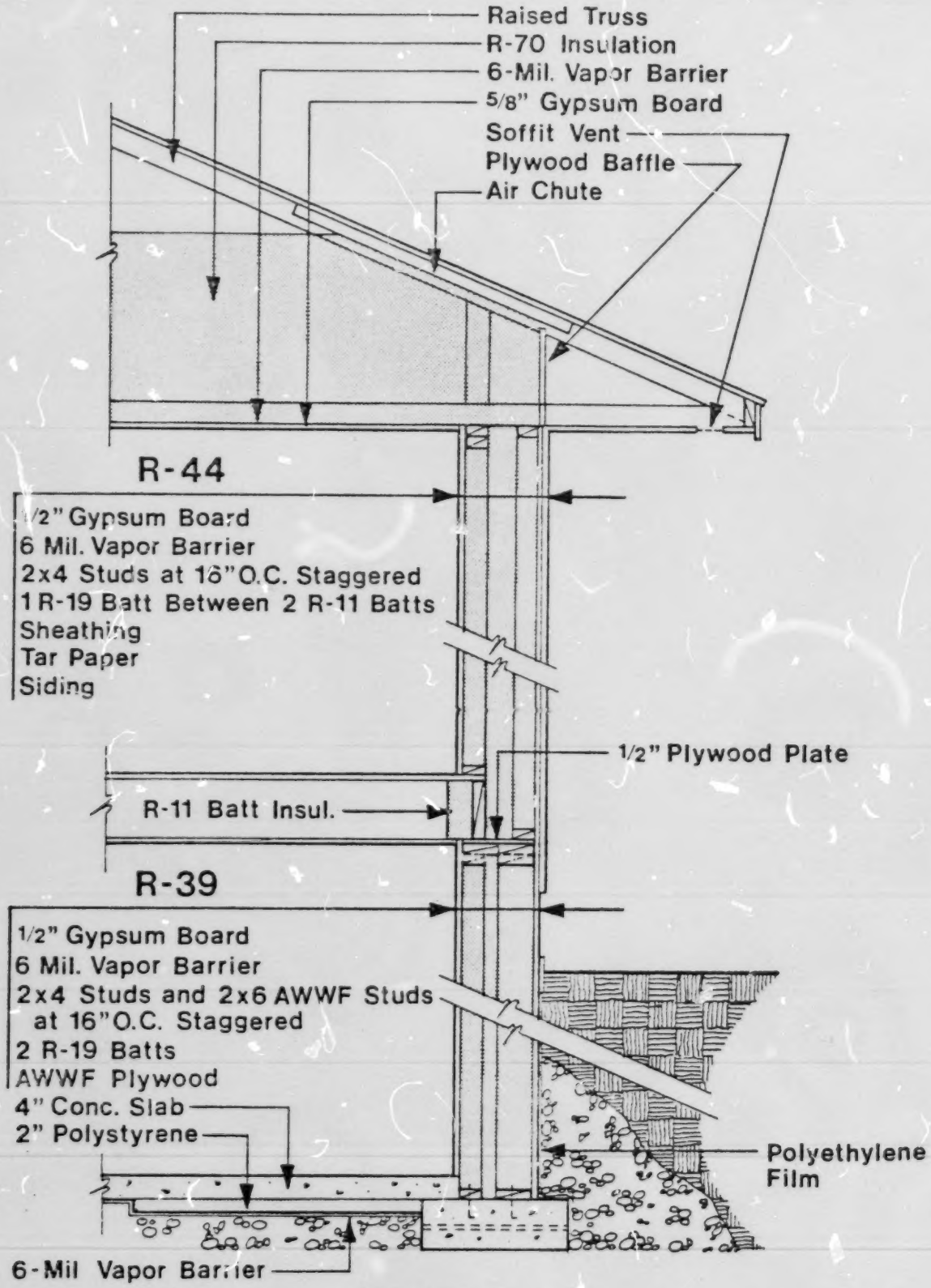


FIGURE IV - 11

DOUBLE WALL WITH WOOD FOUNDATION

retrofits are possible, the exterior strategy is usually the most cost and energy efficient.

(1) Exterior Retrofits are generally accomplished utilizing construction strategies very similiar to new construction strategies. The major problem is vapor barrier detailing and economics. The exterior retrofit requires:

-Removing existing siding

-Wrapping a continuous vapor barrier from soffit to footings

-Sealing the vapor barrier (especially around external openings)

-Adding new required structual framing

-Insulate, insulate and insulate

-Add new exterior sheathing

-Reside

The exterior retrofit has a number of advantages. It does not disrupt the inside of the house. No interior space is lost. Life inside the house can continue uninterupted. Finally, the new exterior becomes thermal protection for the interior wall, creating additional thermal mass to the home.

(a) Rigid board exterior insulation systems are light-weight and can be applied to practically any load bearing exterior wall, whether it be masonary, brick, gypsum sheathing, or wood framed walls. Several techniques can be used for the installation of these insulation boards.

The most common, is simply using very long nails or screws to fasten the foam. Up to 4" of insulation board may be carried by

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* The Superinsulated Retrofit Book, by Marshall and Argue, contains a complete discussion of both interior and exterior retrofits with excellent graphics.

an angle iron fastened to the sill.

Good flashing details are very important. Many insulated boards are not impervious to water. If moisture is permitted inside the foam, R-value will be greatly reduced. It could also freeze and separate from the exterior wall. The disadvantages are the expense of foam boards and that it is difficult to attach siding. A number of stucco like finishes exist for covering exterior board insulation.

(b) Crosshatching or strapping similiar to the Alaskandinavian technique may also be used for retrofit. The added framing lumber is applied to the exterior (Figure IV-12). This system provides a great deal of flexibility (especially for the do-it-yourselfer), since it requires few exact measurements except for windows and doors.

After applying a continuous vapor barrier, the wall must be cross-hatched several times to get the necessary R-30+ wall thickness. The thicker wall also guarantees a dew point will not be reached in the wall.

The limitations of this method include:

- -the large amount of lumber required to place several layers of crosshatching,
- -the number of thermal bridges created,
- -the shear weight placed on the existing wall,
- -problems involving good support for the added wall thickness, and
- -the difficulty in maintaining the vapor barrier integrity through all the required construction.

(2) Interior retrofits are the most complex and costly. However, those who do not wish to disturb the house exterior surface have used this option. The handling of the vapor barrier and insulating is extremely difficult between partition walls (Figure IV-13) and floors.

To create a continuous vapor barrier from floor-to-floor, the rim joist cavities at the perimeter of the exterior walls must be exposed. (Figure IV-14) This requires either the ceiling or sub-floor or both, be removed.

A major limitation is the disruption of life inside as interior surfaces are demolished. Without building a completely new interior wall, there exist two basic options.

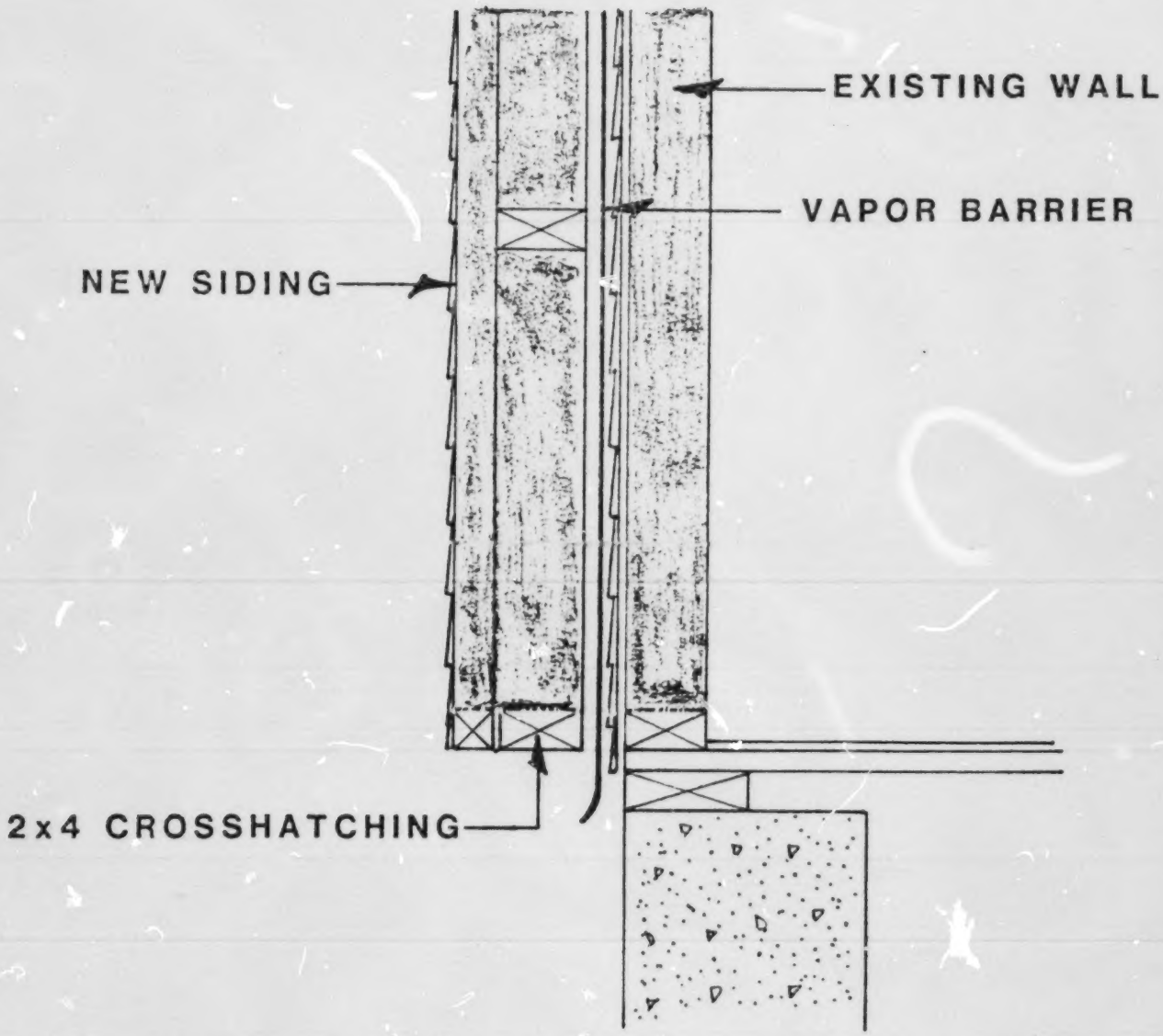


FIGURE IV - 12

EXTERIOR RETROFIT

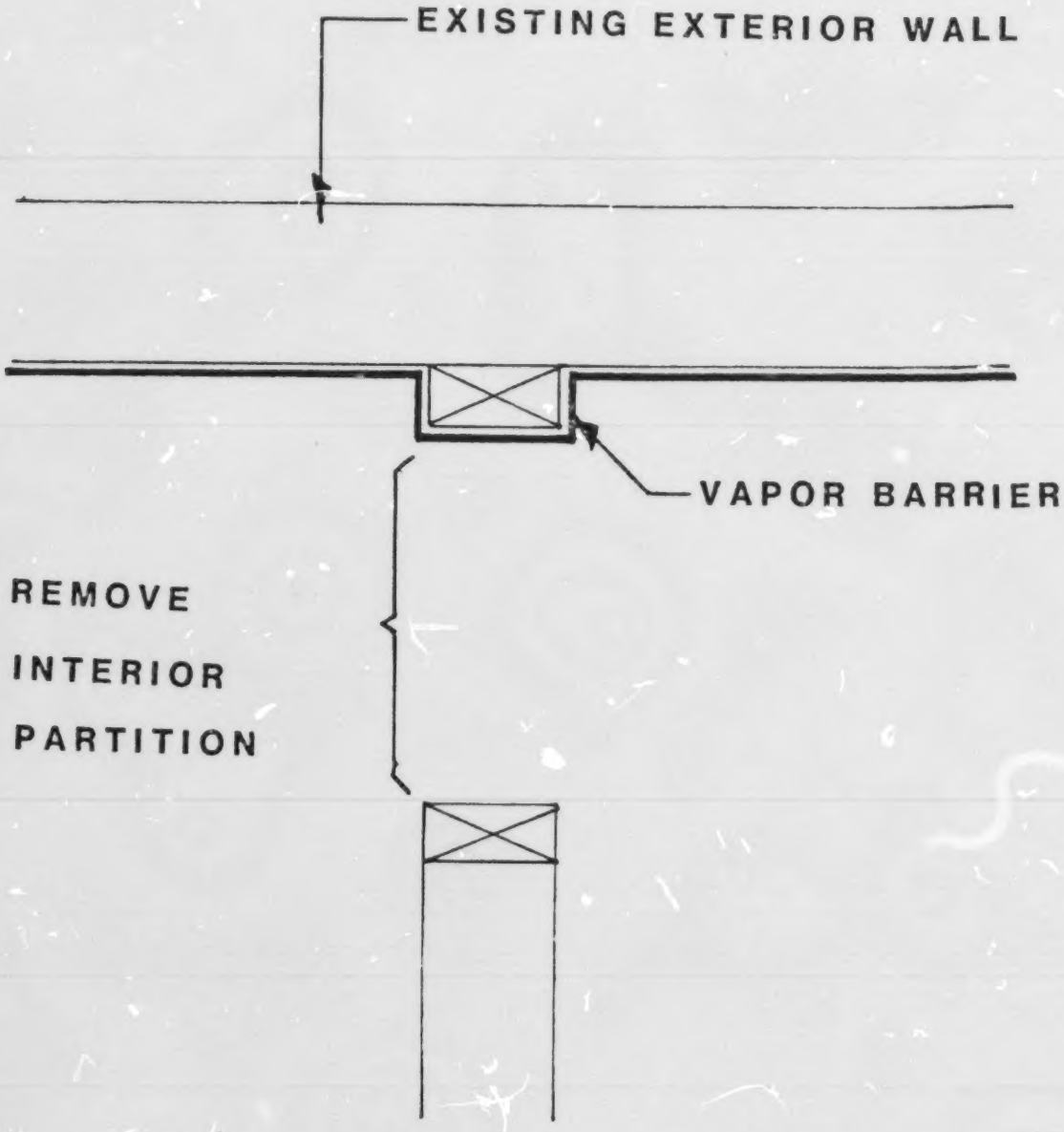
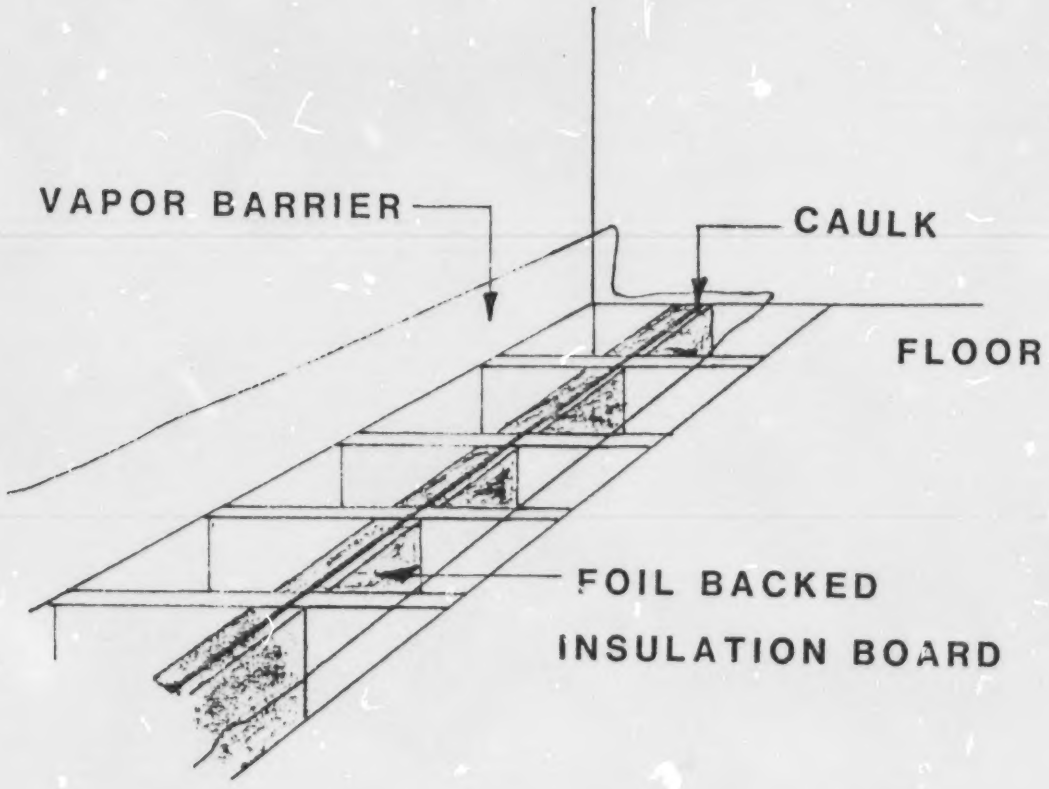


FIGURE IV - 13

RETROFIT VAPOR BARRIER AT INTERIOR AND EXTERIOR WALLS



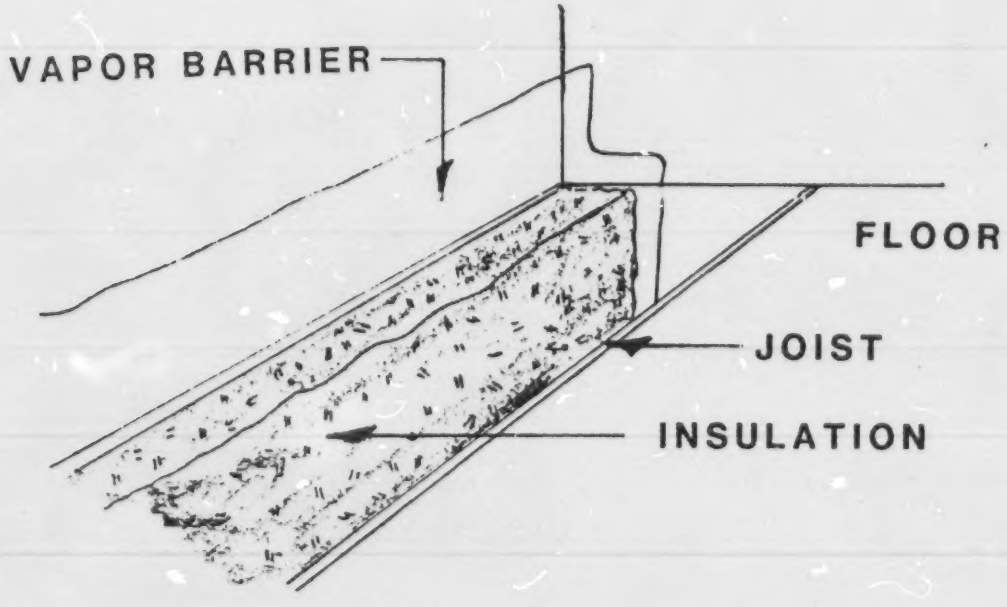


FIGURE IV - 14

RETROFIT OF VAPOR BARRIER AT JOISTS

(a) Rigid board insulation can be applied to interior walls over the existing drywall. Typically a foil backed insulation board with a foil tape across the seams forms the vapor barrier. Then a wall covering is applied. The problem areas involve vapor barrier installation for wall penetrations (e.g., utility runs), between floors and partition walls. Also electrical boxes should be extended to the new wall surface (Note: check electrical inspector for specifics).

(b) Alaskandinavian or crosshatching is another option. After removing the old drywall, spacers can be used to extend the existing wall, a vapor barrier applied and the crosshatching constructed to avoid vapor barrier penetrations.

D. DOUBLE WALL STRATEGIES: RETROFIT CONSTRUCTION

Several techniques, both interior and exterior, involving the construction of existing walls have been used during the past several years. However, as in the single wall retrofit strategies, the exterior application is preferred over the interior.

(1) Exterior retrofits are accomplished most successfully by modifying the Canadian wall construction strategy. Two basic alternatives have been developed and applied in Saskatchewan. Both involved the construction of new curtain walls away from the existing shell. (Figure IV- 15).

The first involves attaching mechanically fastened spacer blocks at the base and top to the existing structural wall. Then, crosshatching can be used to extend the wall outward before the curtain wall is attached. A very strong mechanical bond must be maintained between the spacer blocks and curtain wall. This will require a substantial investment in time, as will the detailing required for the crosshatching and installation of the curtain wall to the spacer blocks.

The most successful method of retrofitting existing houses is extended or building a new ledger plate around the perimeter of the house (Figure IV-16). Several methods exist to accomplish this goal including the use of angle iron lagged into the building. Some crosshatching may be required on the existing frame to ensure a strong structual tie to the new curtain wall being built.

In either case, the first step requires the home to be carefully wrapped in a 6 mil vapor barrier (The vapor barrier blocks inside water vapor from condensing in the new walls, while also preventing cold outside air from entering the house.) Also, both door and window casings must be extended to the new wall thickness (Figure IV-17).

(2) Interior retrofits can be accomplished with the construction of a new interior non-bearing framed wall. As with single wall retrofit construction, or U.S. double wall construction strategies, a number of weak spots in the home are created. For example, in the retrofit, problems with thermal bridging will occur at interfaces with foundation walls, floor joists, window casings, interior partition walls, ceilings, etc. Building a new interior wall can also subtract valuable floor space. Yet the major problem is installing the air-tight vapor barrier, especially in these weak spots. If not properly sealed, the 25 pounds of water vapor generated each day, by a family of four, can enter the cavities and create a dew point and the potential for structual damage.

The wall construction strategies described and shown in the figures have stressed the care required for continuous vapor barriers between floors, walls, and ceilings. The objective is to make the new or retrofit super-

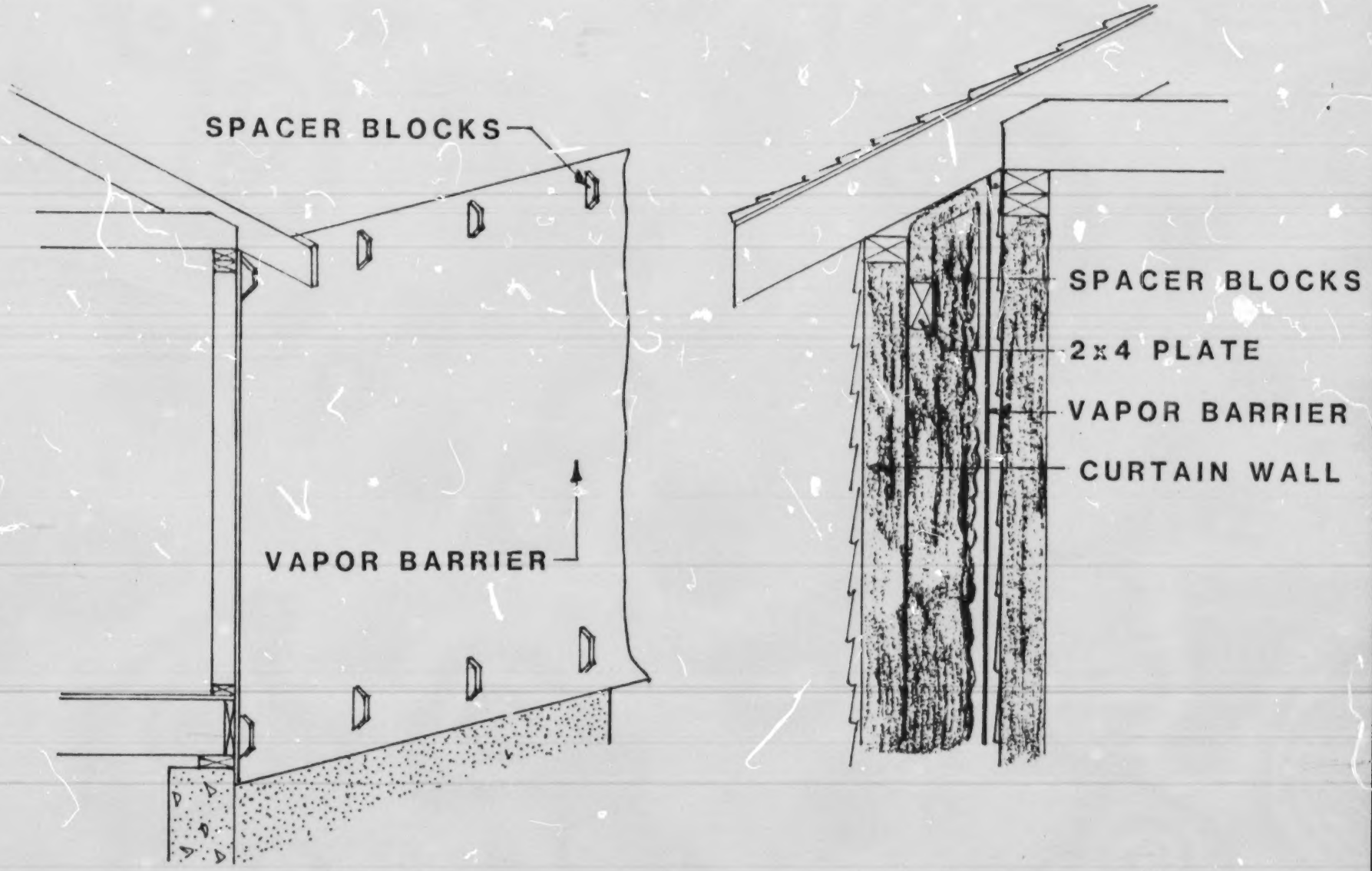
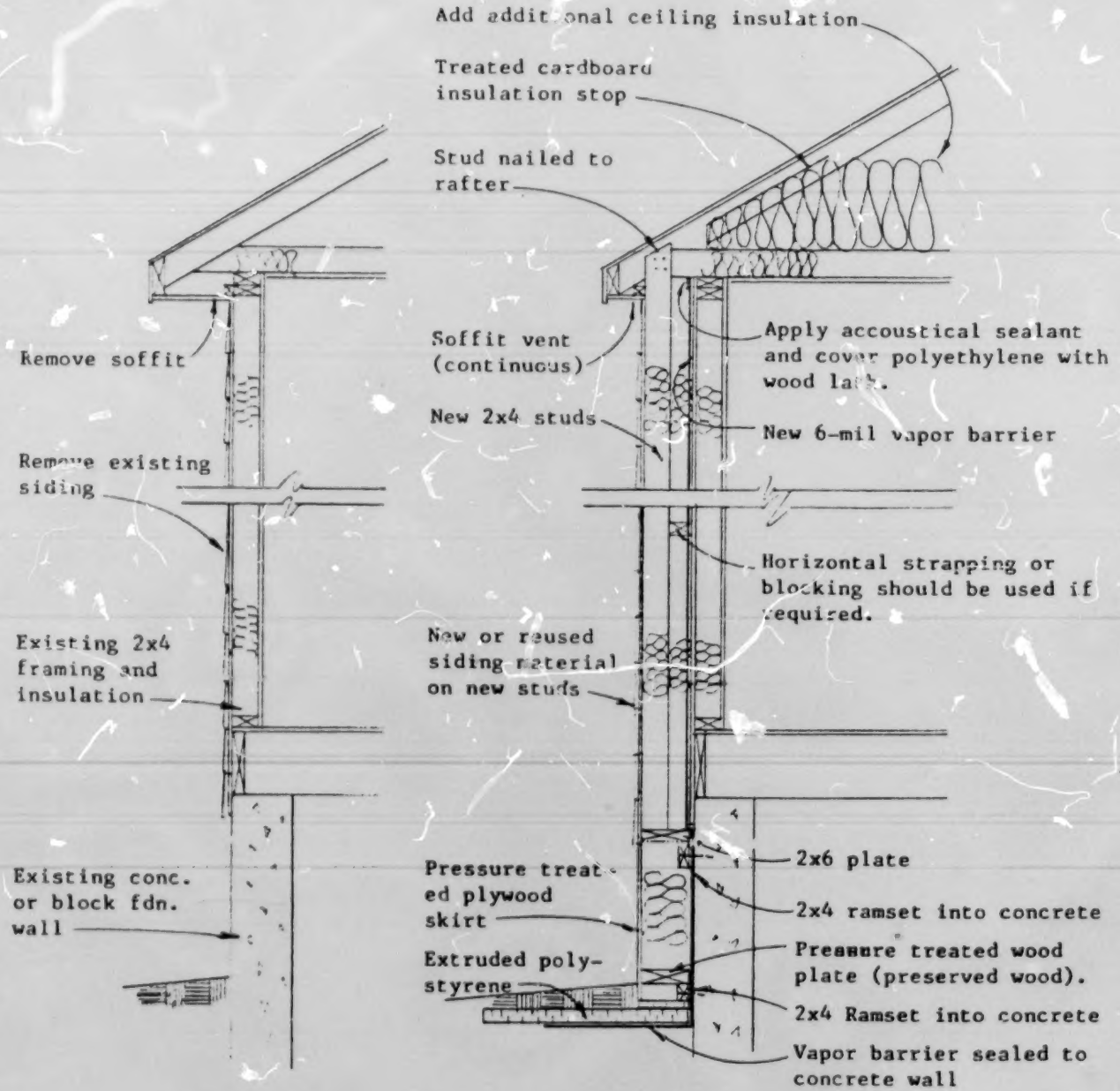


FIGURE IV - 15

CURTAIN WALL ATTACHMENT

NOTE: These sections illustrate a technique used to insulate an existing house from the outside.


Add additional ceiling insulation
Treated cardboard insulation stop
Stud nailed to rafter
Remove soffit
Soffit vent (continuous)
Apply accoustical sealant and cover polyethylene with wood lath.
New 2x4 studs
New 6-mil vapor barrier
Remove existing siding
Horizontal strapping or blocking should be used if required.
Existing 2x4 framing and insulation
New or reused siding material on new studs
Existing conc. or block fdn. wall
Pressure treated plywood skirt
2x6 plate
2x4 ramset into concrete
Extruded poly-styrene
Pressure treated wood plate (preserved wood).
2x4 Ramset into concrete
Vapor barrier sealed to concrete wall

EXISTING HOUSE WALL

REFITTED SUPERINSULATED WALL

IV - 26

FIGURE IV - 16

NOTE: The integrity of the vapor barrier is critical. Repair any damaged areas or undesired penetrations. Seal all joints and edges with a non-hardening butyl caulk.

MINNESOTA ENERGY AGENCY - SUPER INSULATED HOME DEMONSTRATION PROJECT

DRAWING TITLE: RETROFIT OF EXTERIOR WALLS DRAWING NUMBER SW-10(a)

DRAWN BY: TG/KWH DATED: 3/1/82 SCALE: None REFERENCE: D-10

980 American Centre Bldg., 150 East Kellogg Blvd., St. Paul, Minnesota 55101

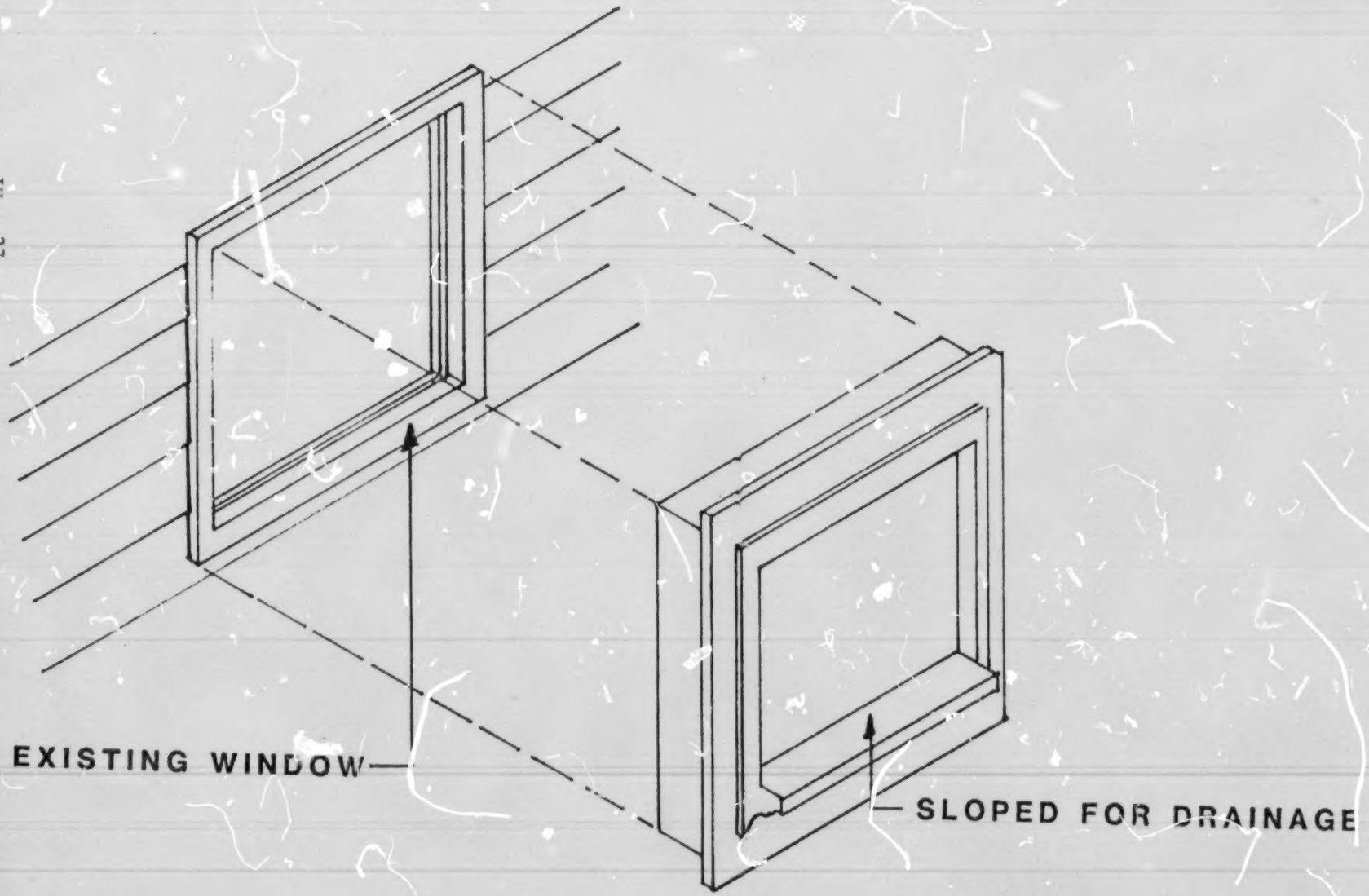


FIGURE IV - 17

WINDOW CASING DETAIL

insulated home as tight as possible. This is relatively straight forward in new construction. However, this becomes extremely difficult in most retrofit applications.

The superinsulation construction strategies described cover most of current state-of-the-art. There are many combinations of the ones described. The one selected, again, depends upon the construction strategy of the other house components and builder preference.

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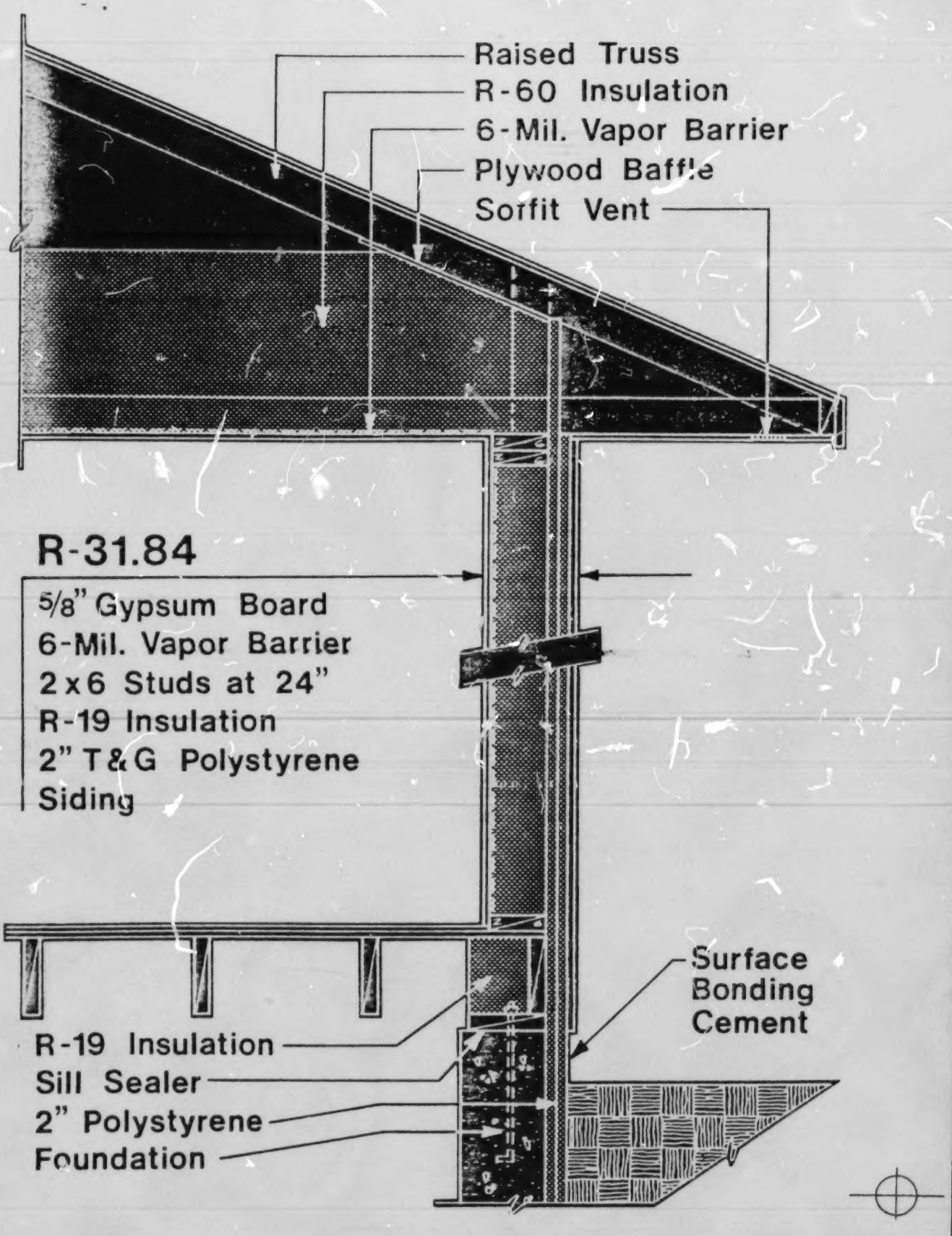
James Martin (Minneapolis, MN). Solar Saltbox, P & M Construction, Northfield, MN.


Raised Truss
R-60 Insulation
6-Mil. Vapor Barrier
Plywood Baffle
Soffit Vent
R-31.84
5/8" Gypsum Board
6-Mil. Vapor Barrier
2x6 Studs at 24"
R-19 Insulation
2" T&G Polystyrene
Siding
Surface
Bonding
Cement
R-19 Insulation
Sill Sealer
2" Polystyrene
Foundation

V. ATTICS

TABLE OF CONTENTS

	PAGE
A. ATTIC: NEW CONSTRUCTION	3
B. ATTIC: RETROFIT	10
C. ROOF OVERHANG SIZING AND SHAPING	14
D. BIBLIOGRAPHY	17

--INTRODUCTION--

Creating a superinsulated attic requires 16 inches (R-50+) or more of insulation. The problem facing superinsulated builders is designing and building a superinsulated attic deep enough for the extra thick level of insulation, while also providing enough space for proper ventilation (Figure V-1).

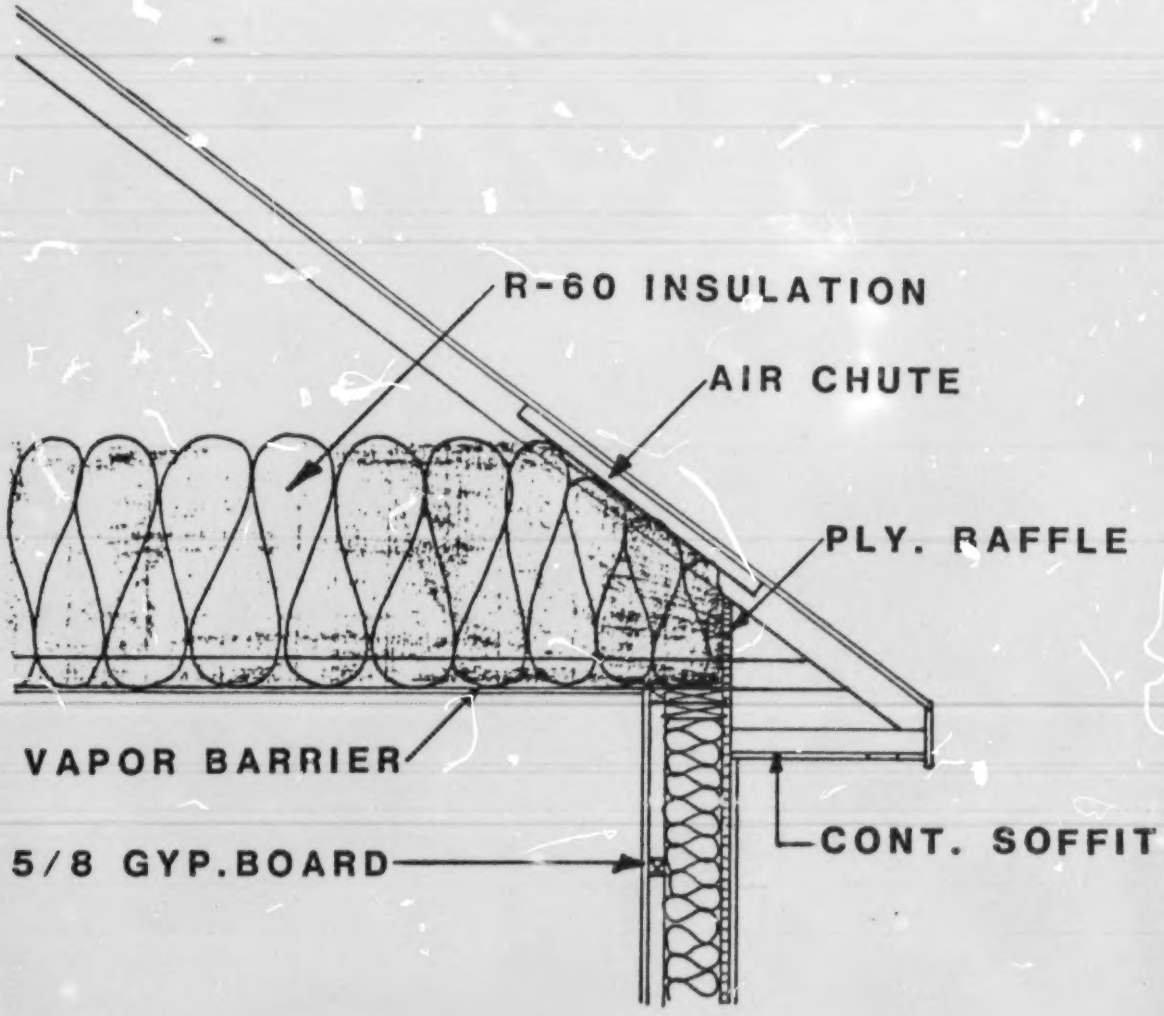


FIGURE V - 1

ATTIC VAPOR BARRIER AND INSULATION DETAIL

A. ATTIC: NEW CONSTRUCTION

A common method for allowing sufficient space for insulation and ventilation is the raised "energy" truss. The energy truss serves several purposes beyond weather protection and a structural tie between the outside walls.

(1) It creates the deep ceiling cavity necessary for the extra thick amounts of insulation. The overhangs can be extended over walls to avoid thermal gaps. The greater structural strength allows longer clear spans providing more flexibility for the lay-out of interior partition and vapor barrier installation (Figures V-2, V-3, V-4, and V-5).

(2) Another benefit of the energy truss is the extension of roof overhangs. Ideally, the southern overhang should be zero in the heating season, and large enough to prevent direct sunshine from heating the window in the cooling season. In general, 2 foot overhangs are adequate for most Minnesota latitudes. If the overhang is insufficient to fully block the summer sun, special reflective films or shutters can reduce the unwanted solar gain (see Figure V-6).

(3) The energy truss also provides enough space for air circulation over the top of the insulation. Superinsulated homes use existing building components and techniques. They, like other homes, need ventilation.

ATTIC

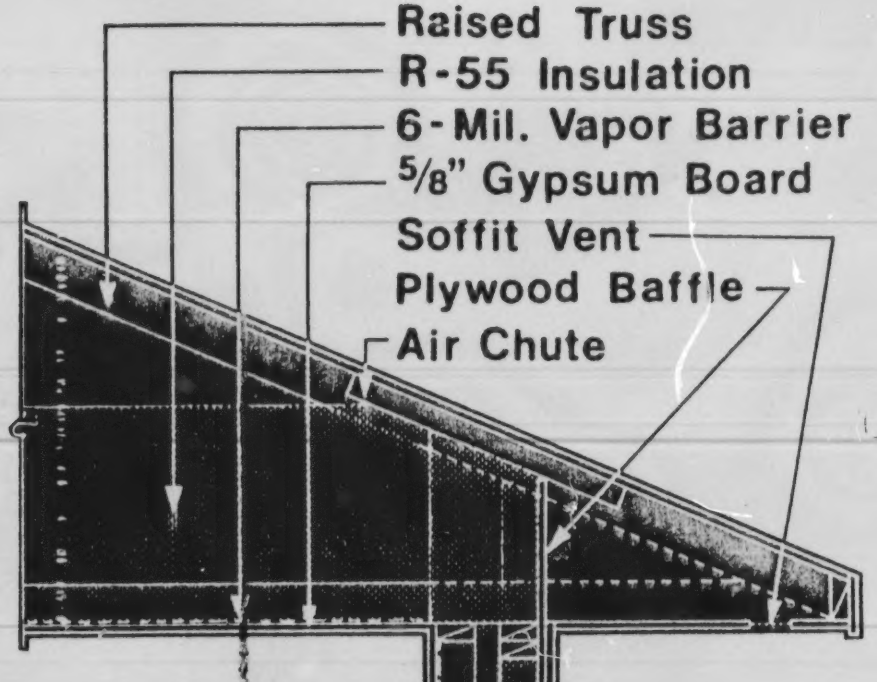
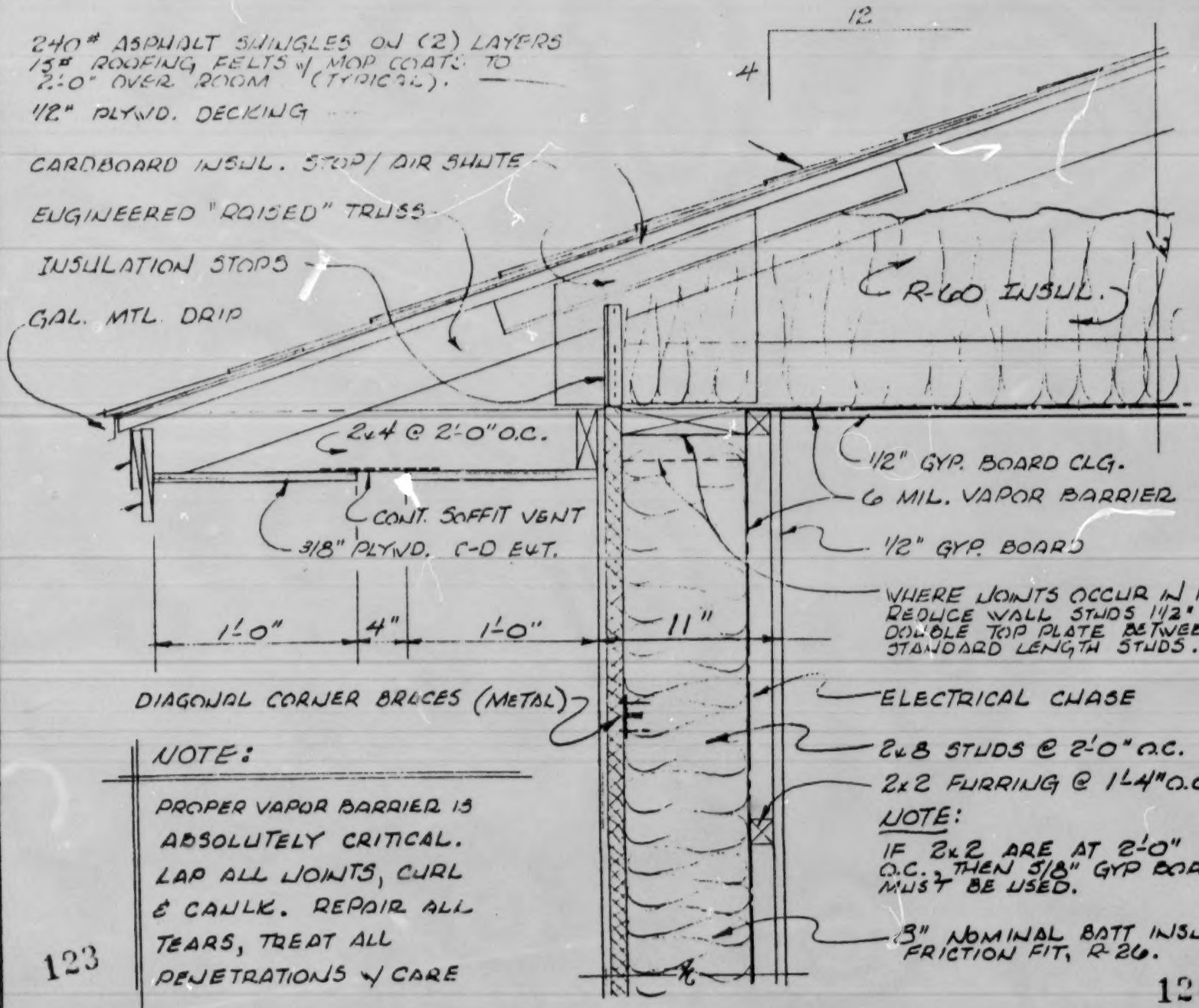


FIGURE V-2

SUPERINSULATION LTD.


240# ASPHALT SHINGLES ON (2) LAYERS 15# ROOFING FELTS w/ MOP COATS TO 2'-0" OVER ROOM (TYPICAL).
1/2" PLYWD. DECKING
CARDBOARD INSUL. STOP/ AIR SHUTE
ENGINEERED "RAISED" TRUSS
INSULATION STOPS
GAL. MTL. DRIP
12
4
R-60 INSUL.
2x4 @ 2'-0" O.C.
CONT. SOFFIT VENT
3/8" PLYWD. C-D EXT.
1'-0"
4"
1'-0"
11"
DIAGONAL CORNER BRACES (METAL)
1/2" GYP. BOARD CLG.
6 MIL. VAPOR BARRIER
1/2" GYP. BOARD
WHERE JOINTS OCCUR IN PLATE, REDUCE WALL STUDS 1 1/2" and DOUBLE TOP PLATE BETWEEN STANDARD LENGTH STUDS.
ELECTRICAL CHASE
2x8 STUDS @ 2'-0" O.C.
2x2 FURRING @ 1'4" O.C.
NOTE:
IF 2x2 ARE AT 2'-0" O.C. THEN 5/8" GYP BOARD MUST BE USED.
8" NOMINAL BATT INSUL., FRICTION FIT, R-26.

NOTE:

PROPER VAPOR BARRIER IS ABSOLUTELY CRITICAL. LAP ALL JOINTS, CURL & CAULK. REPAIR ALL TEARS, TREAT ALL PENETRATIONS W/ CARE

FIGURE V - 3

123

124

MINNESOTA ENERGY AGENCY — SUPER-INSULATED HOME DEMONSTRATION PROJECT

DRAWING TITLE: SOFFIT DETAIL

DRAWN BY: [illegible] DATED: 3/1/80 SCALE: 1/2" = 1'-0"

DRAWING NUMBER: SI-20

REFERENCE: D-27

980 American Center Bldg., 150 East Kellogg Blvd., St. Paul, Minnesota 55101

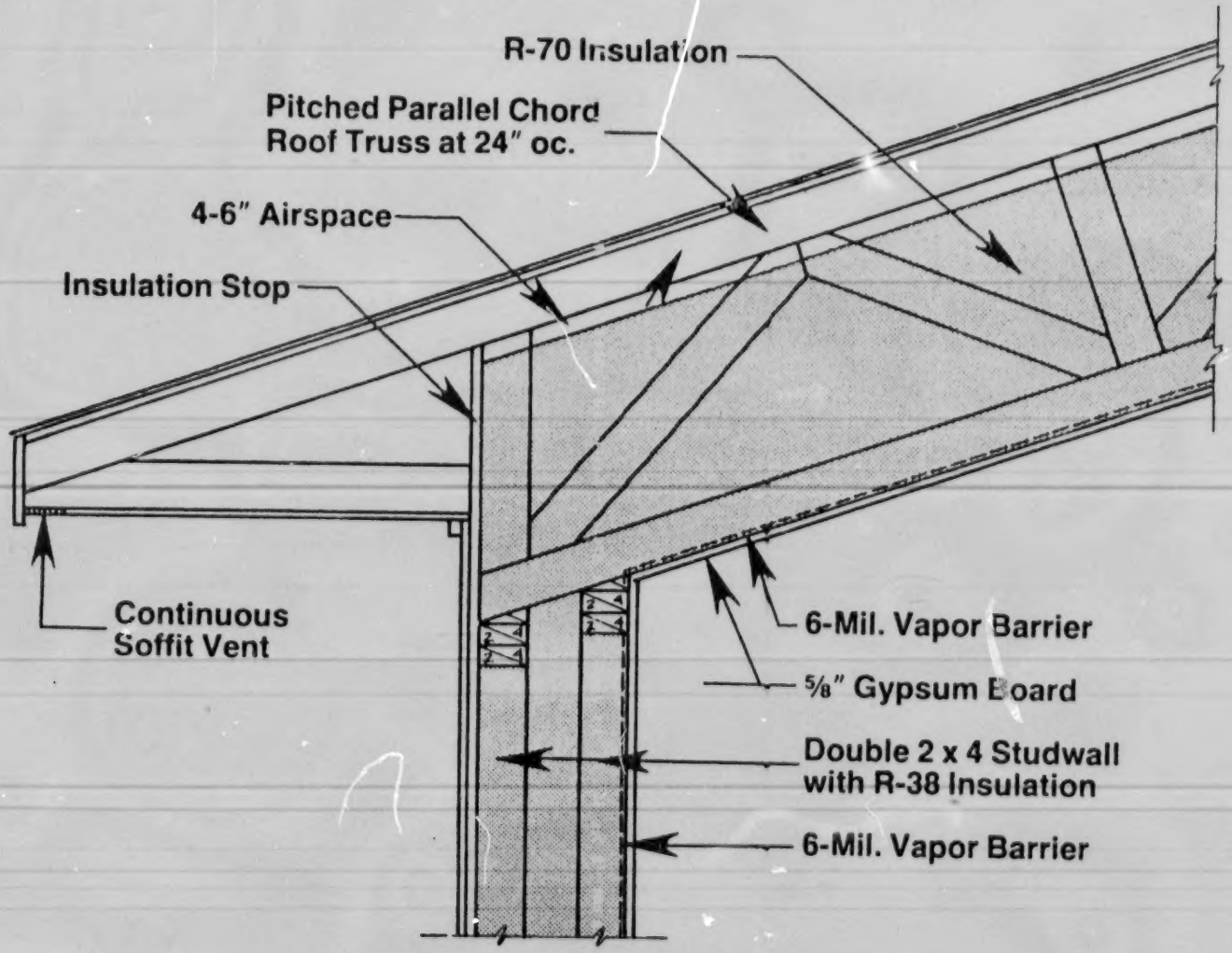


FIGURE V - 4

CATHEDRAL CEILING

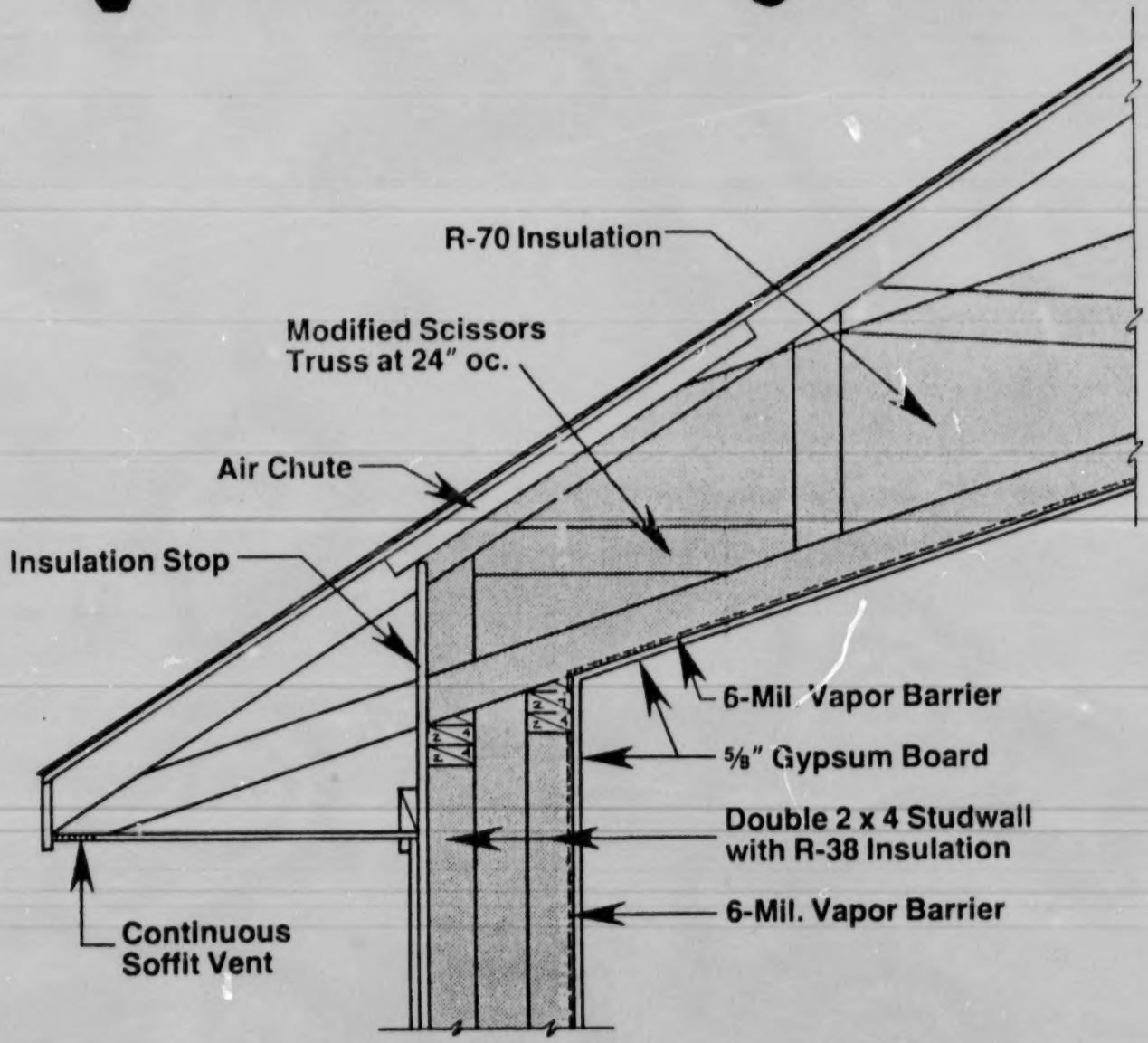


FIGURE V - 5

CATHEDRAL CEILING

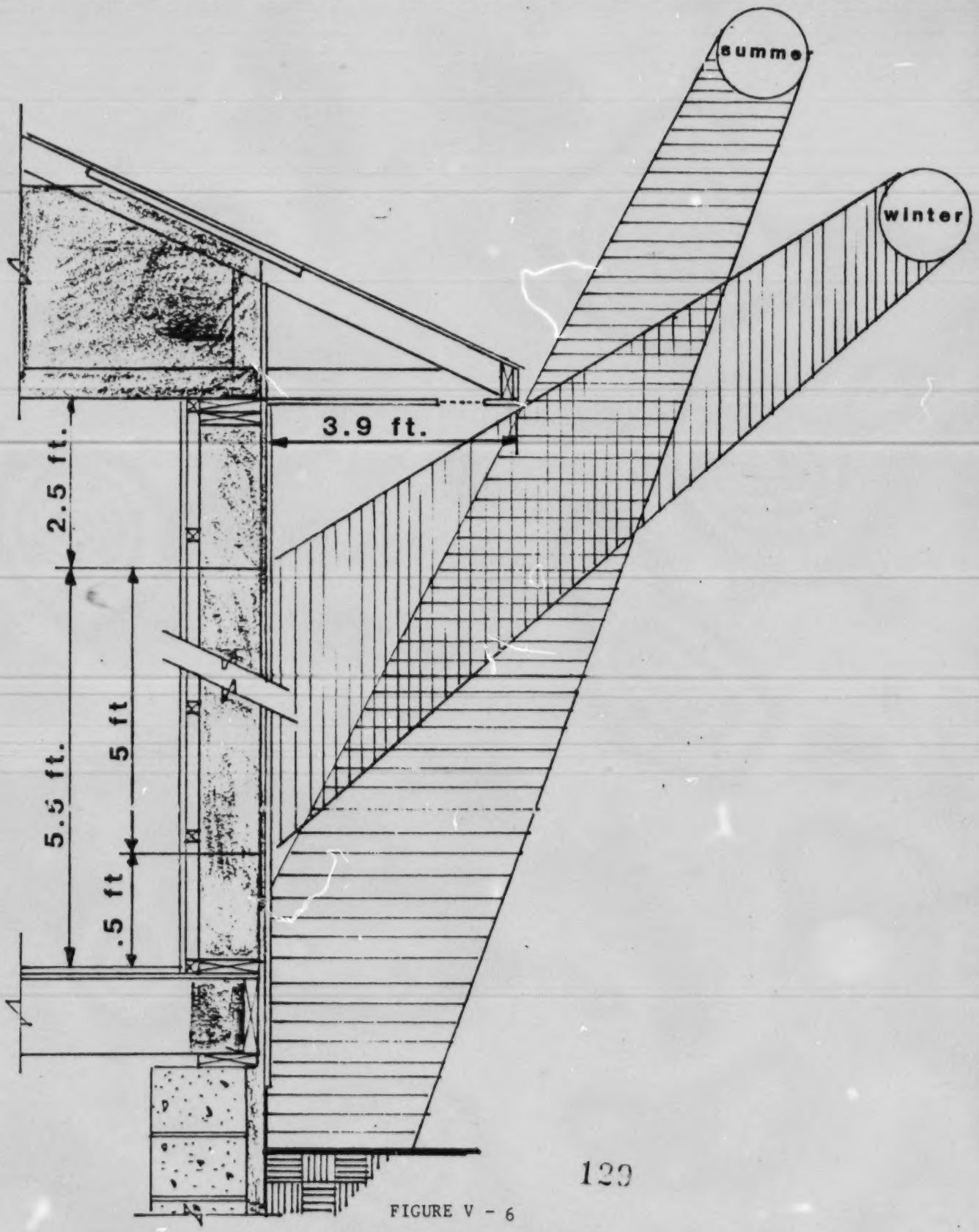


FIGURE V - 6

OVERHANG SIZING FOR WINTER AND SUMMER

The pitched roof and flat ceiling arrangement of the gable or hip trusses allows plenty of ventilation space. Proper ventilation requires 1 ft^2 of ventilation for every 300 ft^2 of attic with vents split evenly between the soffit and peak.

For the cathedral or shed attic where the pitched roof and ceiling follows the roof line, continuous ridge vents with a ratio of 1 ft^2 of ventilation is required for every 150 ft^2 of attic. To keep insects and rodents out, all vents need to be screened. No one alternative is best, several work.

(4) Finally, the typical interior attic hatch (or scuttle) is a primary source of air and water vapor leaks into the cold attic cavity. The interior attic hatch violates the vapor barrier resistant gaskets or magnetic seals. Remember, a carefully sealed continuous vapor barrier is essential to prevent warm air and water vapor from migrating into the cold roof cavity (Figure V-7 and V-8).

An exterior attic hatch is a solution used for this problem in most superinsulated homes. The access door (22" by 30" in size) should be hinged at the top and located at the gable ends or inside an attached garage. However, if there are no gable ends or attached garage, the interior attic hatch is the only alternative.

If attention is payed to detail in attic construction and application of the vapor barrier and insulation, all potential condensation problems

and ice dam problems can be eliminated. No scuttle or other interior access openings should be permitted in a superinsulated house if it can be avoided. All openings drilled in the wall plate for utility runs, such as electrical wires and plumbing vent stacks should be properly sealed. Recessed lighting fixtures should be avoided. Ideally, all electrical wiring should be installed on the "warm" side of the vapor barrier. The vapor barrier must be continuous and extended over the top of all interior partitions. Finally, no finished ceiling or wall covering should be installed until the vapor barrier, insulation and other concealed work has been inspected and approved.

B. ATTIC: RETROFIT

Modifiying an existing attic to superinsulation standards involves the same four concerns required for new construction. However, the implementation of these is much more difficult.

(1) The attic cavity must be increased to hold the additional insulation. The eaves must be modified to avoid creating thermal weak points at the junction of the exterior wall and attic.

(2) Roof overhangs should be increased to provide summer shading.

(3) Provision must be made for adequate ventilation.

(4) The attic hatch must be insulated and sealed.

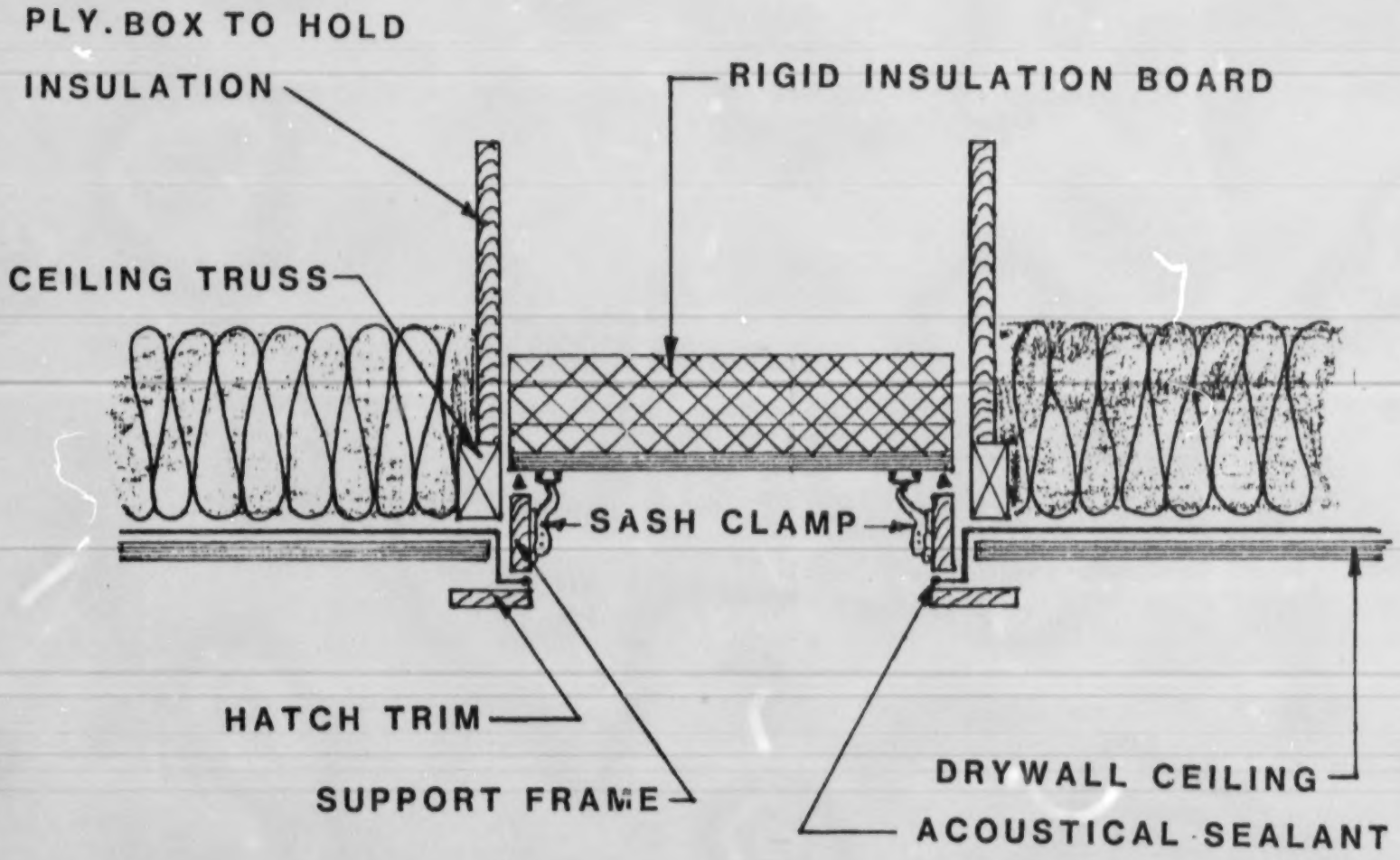


FIGURE V - 7

INTERIOR ATTIC HATCH DETAIL

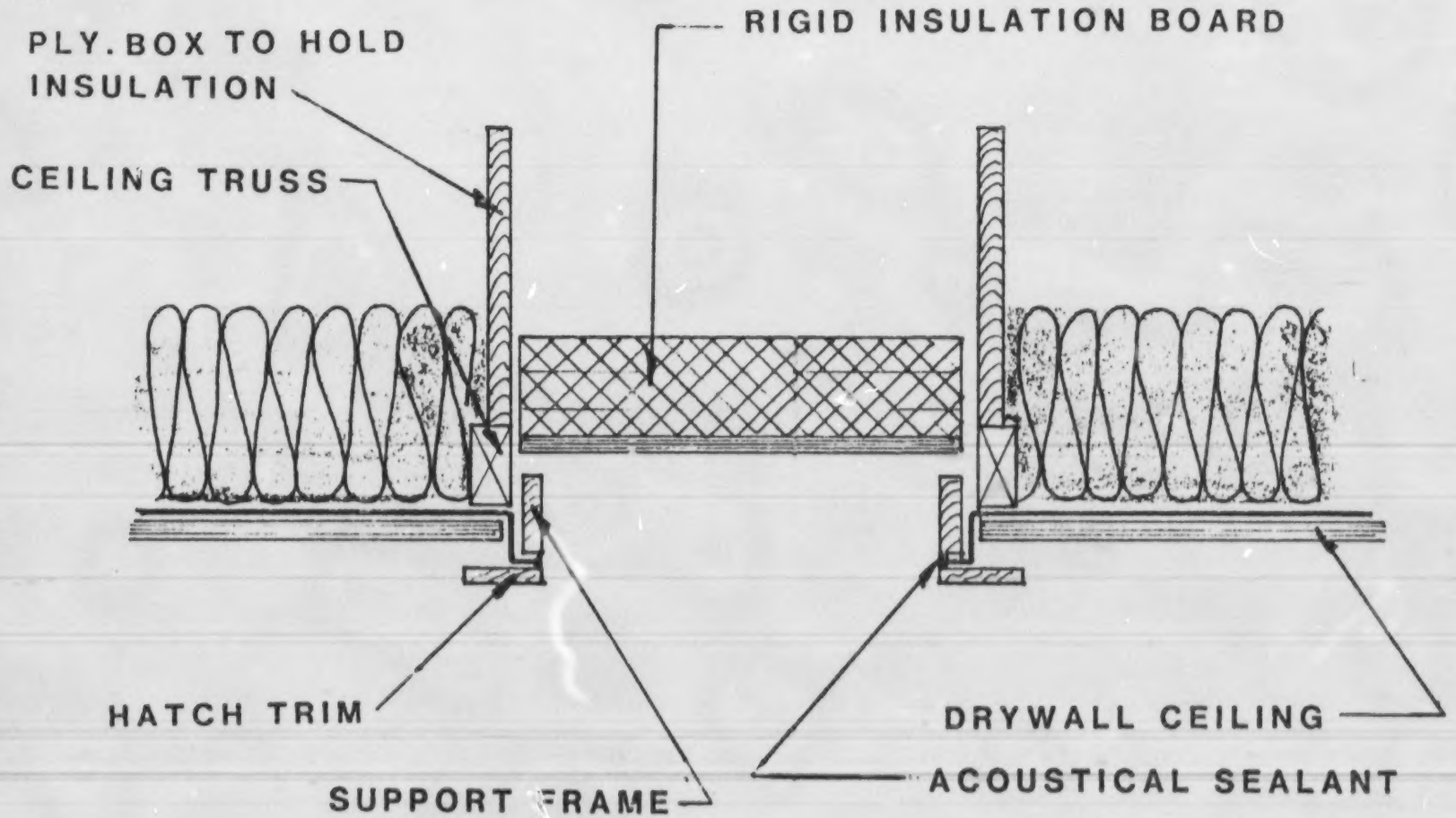


FIGURE V - 8

INTERIOR ATTIC HATCH DETAIL

The continuous vapor barrier is fundamental for all superinsulation construction. In the retrofit, it usually becomes very difficult. Installing a new vapor barrier requires all potential tears or gaps that could lead to air vapor infiltration or exfiltration be sealed. To accomplish this goal, several alternatives exist.

(1) The existing ceiling could be left in place with a new vapor barrier directly applied over the existing drywall. Complete removal of the existing ceiling drywall is another alternative. The vapor barrier is applied under the attic joists similar to new construction. The major difference involves more patching, taping, and caulking around the interior partitions below the ceiling joists and utility runs.

(2) Several measures are necessary around interior partition walls, utility runs, and others where the vapor barrier cannot be applied without demolition.

(3) The vapor barrier can be applied above the rim joists above the partitions and sealed. In spite of all efforts, the vapor barrier will not be continuous. Thus, weak spots for air movement and potential condensation will exist.

The most effective method to avoid the problems involving vapor barriers, ventilation and insufficient cavity size, is either the demolishing of the existing roof or building a new roof over the existing one. These have been the only methods proven effective in the superinsulated retrofits monitored in Sasketchewan the past

several years. Constuction of a new roof is also the only likely alternative for houses with flat and cathedral roofs.

C. ROOF OVERHANG SIZING AND SHADING

A natural extension of the "energy truss" is to use the size and location of the roof overhang for shading. The overhang over south-facing windows is used to control the amount of winter and summer sun entering into the home. Ideally, the overhang should project out above the window to shade in summer, while leaving the window un-shaded during the winter.

An excellent nomograph prepared by Michael Utzinger, "A Simple Method for Sizing Overhangs", is found in the July, 1980 issue of Solar Age.

Table V-1 indicates the overhang size and length of the header space above windows to obtain the number of unshaded winter days/shaded summer days for south-facing glass areas of 4, 4½, and 5 feet in height. Figure V-5 shows how the overhang of the Alaskandinavian wall section with 5 feet high glass window can be sized to provide 120 days of winter sun and 80 days of summer shade. Figure V-5 represents an extreme example where unusually large overhangs are required to optimize winter and summer sun angles. Notice the header space above the window is nearly 2½ feet. More typical window lengths (4 ft and 4½ ft) shown in Table V-1 provide more typical window and overhang dimensions.

In these examples, the overhang and it's shading are designed to the

solar cycle of summer and winter solstices. Unfortunately, the maximum heating or cooling loads generally occur approximately 30 days after either solstice in Minnesota. Thus, even with a perfectly designed overhang, heating or cooling problems could appear in spring or fall. Movable awnings can serve as a solution to this problem.

TABLE V-1 OVERHANG LENGTH SIZING AT 45°N LATTITUDE
(Twin Cities)

Unshaded Winter Days / Shaded Summer Days	Length of Overhang	Length of Wall above Glass	Length of Glass
120 / 60	2.7 ft	1.7	4.0 ft
	3.0	1.9	4.5
	3.3	2.1	5.0
120 / 80	3.1	2.0	4.0
	3.5	2.2	4.5
	3.9	2.5	5.0
100 / 80	2.9	1.6	4.0
	3.2	1.8	4.5
	3.5	2.0	5.0
100 / 60	2.5	1.3	4.0
	2.8	1.5	4.5
	3.1	1.7	5.0

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VI. FOUNDATIONS

TABLE OF CONTENTS

	PAGE
A. FOUNDATION WALLS: NEW CONSTRUCTION	3
B. FOUNDATION FLOORS: CEMENT SLABS	14
C. FOUNDATION WALLS: RETROFIT CONSTRUCTION	14
D. FOUNDATION FLOORS: RETROFIT	16
E. BIBLIOGRAPHY	19

--INTRODUCTION--

Heat loss around the foundation can account for nearly a fourth of the heat loss in conventional homes. The uninsulated basement floor in a superinsulated home can account for up to 40% of the heating bill.

The basement foundation should be heavily insulated and protected to avoid heat loss and moisture problems. The Robinson Rules-of-Thumb specifies any exposed basement wall R-values should be equal to the above grade R-values. Basement walls below grade should be insulated to R-values equal to 75% of above grade wall values. Basement floors should be insulated to R-values equal to 35% of above grade wall R-values. A 6-mil vapor barrier should be used on walls and under the floor. Whether poured concrete, concrete block, or wood foundations are used, depends on regional builder experience and climate. However, the wood foundation is more cost effective if the below grade living area is to be superinsulated. The strategy for superinsulating either varies slightly.

In selecting the proper foundation insulating technique, pay close attention to the compatability of the insulating method and materials with the entire construction process.

To Control Foundation Heat Loss:

(1) Caulk (or foam) the joint between sill and foundation and around window frames.

(2) Weatherstrip basement windows.

(3) Insulate rim joists or headers inside and out.

(4) Insulate the basement wall, preferably on the outside. The exposed above-grade insulation should be covered by a protective coating of asbestos cement, cement parging, or some other method.

In addition, methods to control retrofit heat loss include:

(5) Isolate the basement and make it an unheated area (i.e., creat the basement as a crawl space) or

(6) Trench around the exterior, waterproof and insulate; or

(7) Erect new interior frame walls and insulate; or

(8) Insulate foundation slab floors by building a new insulated floor over the existing one.

Which ever strategy is used, two points must be stressed:

-Make sure the vapor barrier is continuous.

-Insulate walls continuously (incomplete applications encourage thermal differentials, frost heave and foundation failure).

A. FOUNDATION WALLS: NEW CONSTRUCTION

(1) Block or poured cement foundations should always be insulated to the outside. For split level structures, a compromise version using insulation can use the insulated foam sheathing to the outside while also insulating to the inside. However, it is important to place at least R-10 to the outside to provide the important thermal break and also provide protection against frost heave. (Figures VI-1 through VI-4). The exterior insulation board must be moisture resistant (e.g., extruded polystyrene) and protected if above grade(Figure VI-3). The exterior insulation board should be applied directly against the foundation wall, as opposed to horizontally outward from the wall.

Vapor barrier application at the interior wall and concrete floor is shown by Figure VI-3. Figure VI-4 shows how insulation board can be utilized to solve potential basement box header (or rim joist) vapor barrier problems.

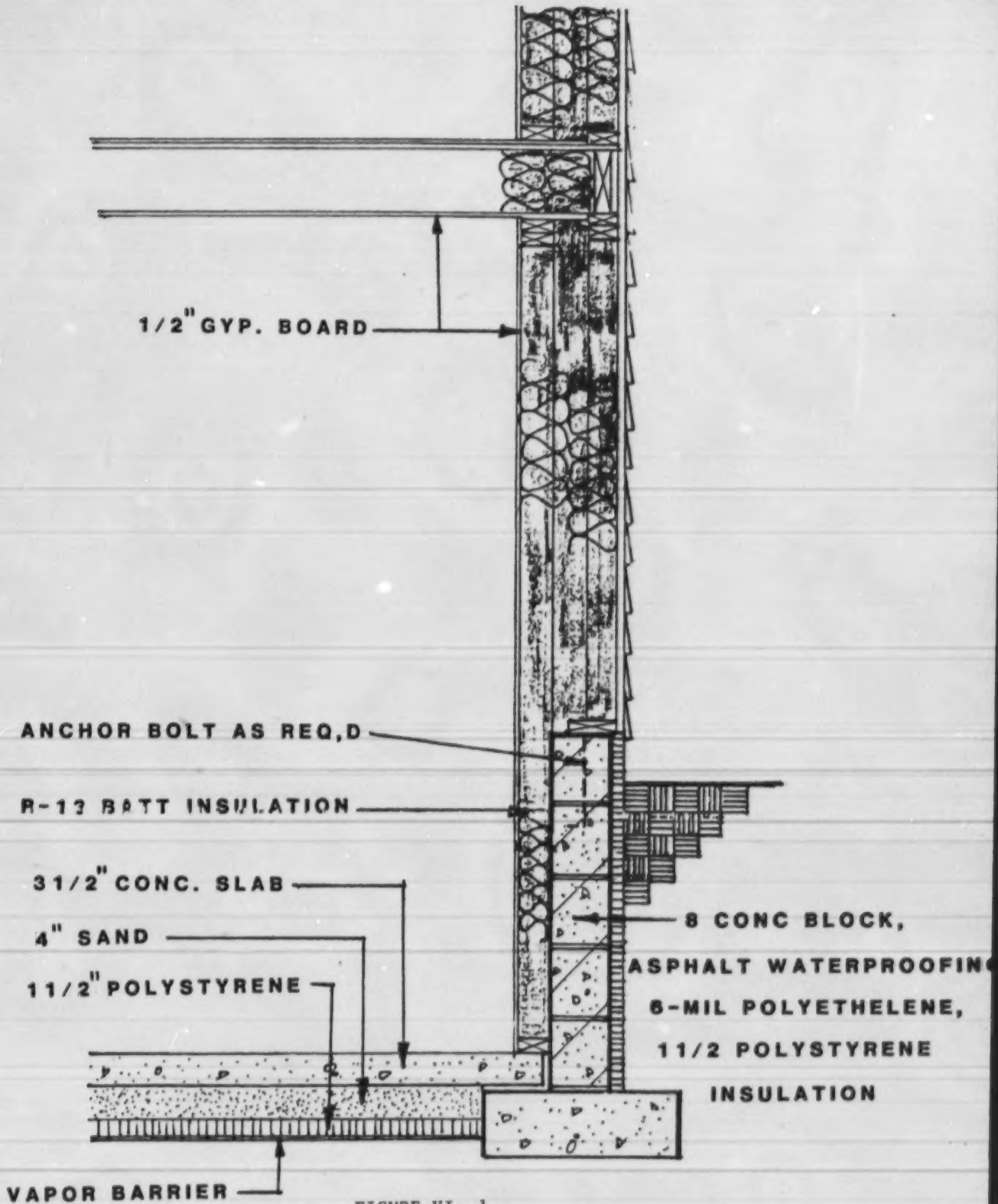

FIGURE VI- 1

SPLIT LEVEL DOUBLE CONSTRUCTION

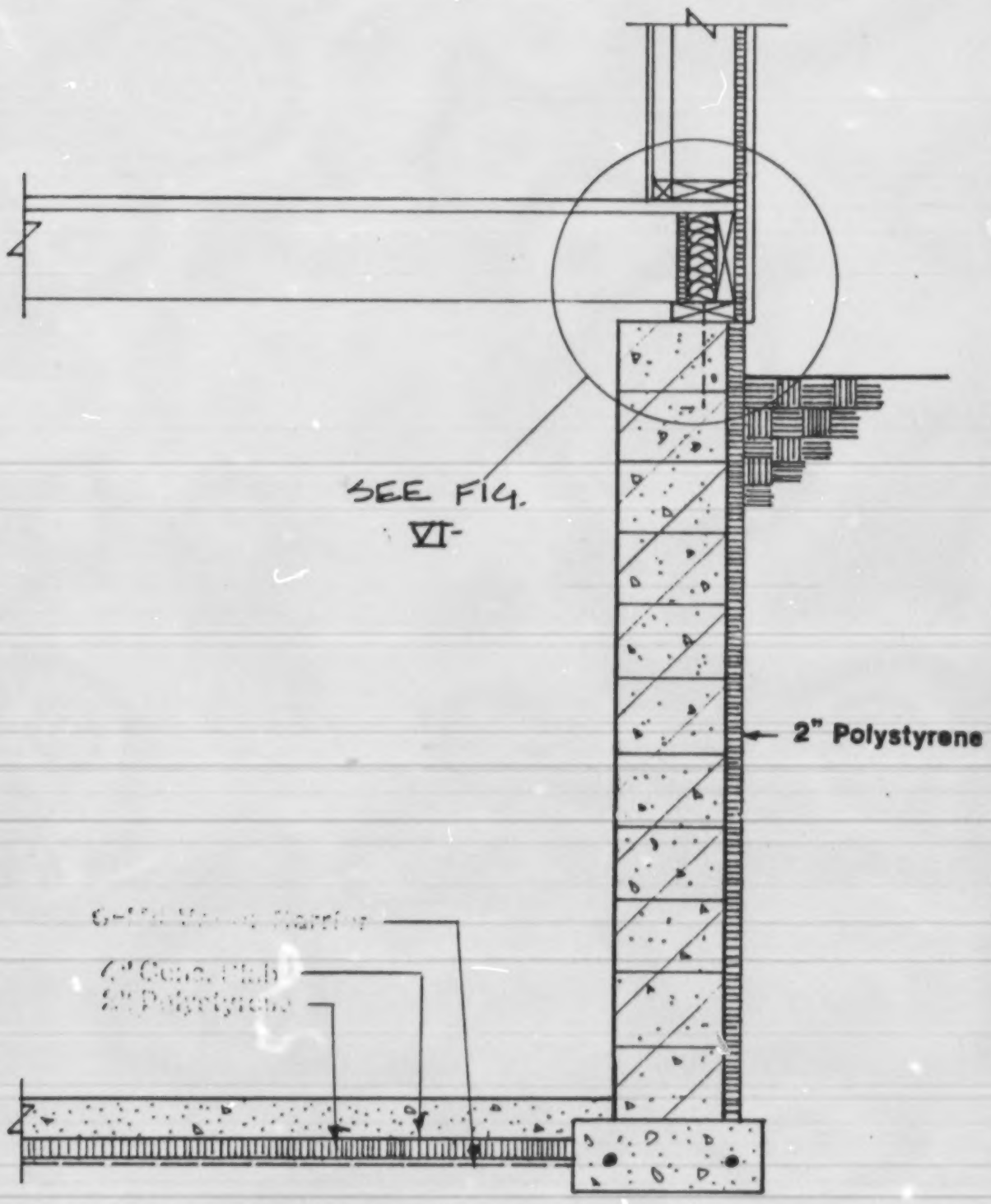

Fig. VI - 2

BASEMENT WALL AND
FLOOR READY FOR INTERIOR
FINISHING

VI-5

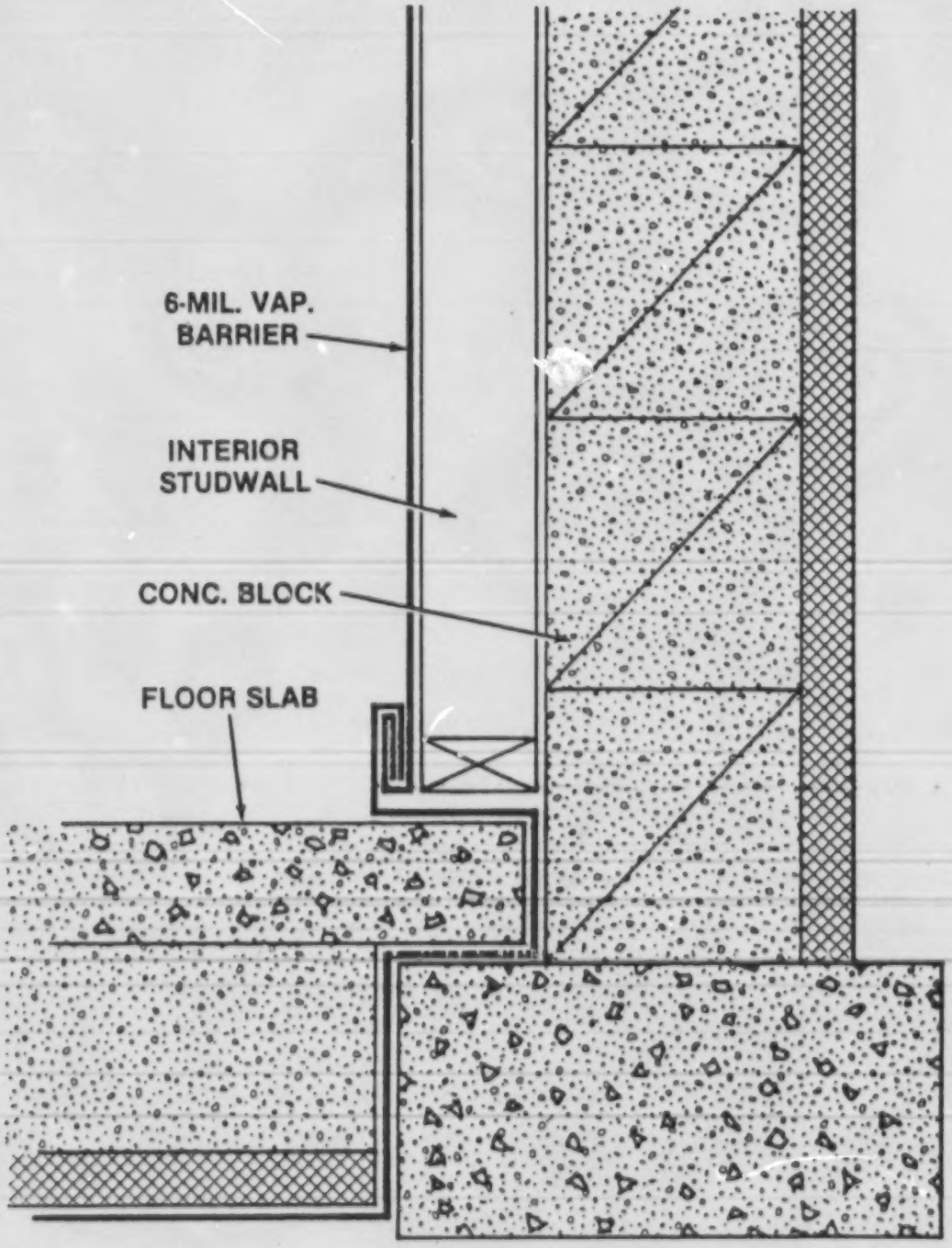

FIGURE VI - 3

VAPOR BARRIER AT WALL AND CONCRETE FLOOR

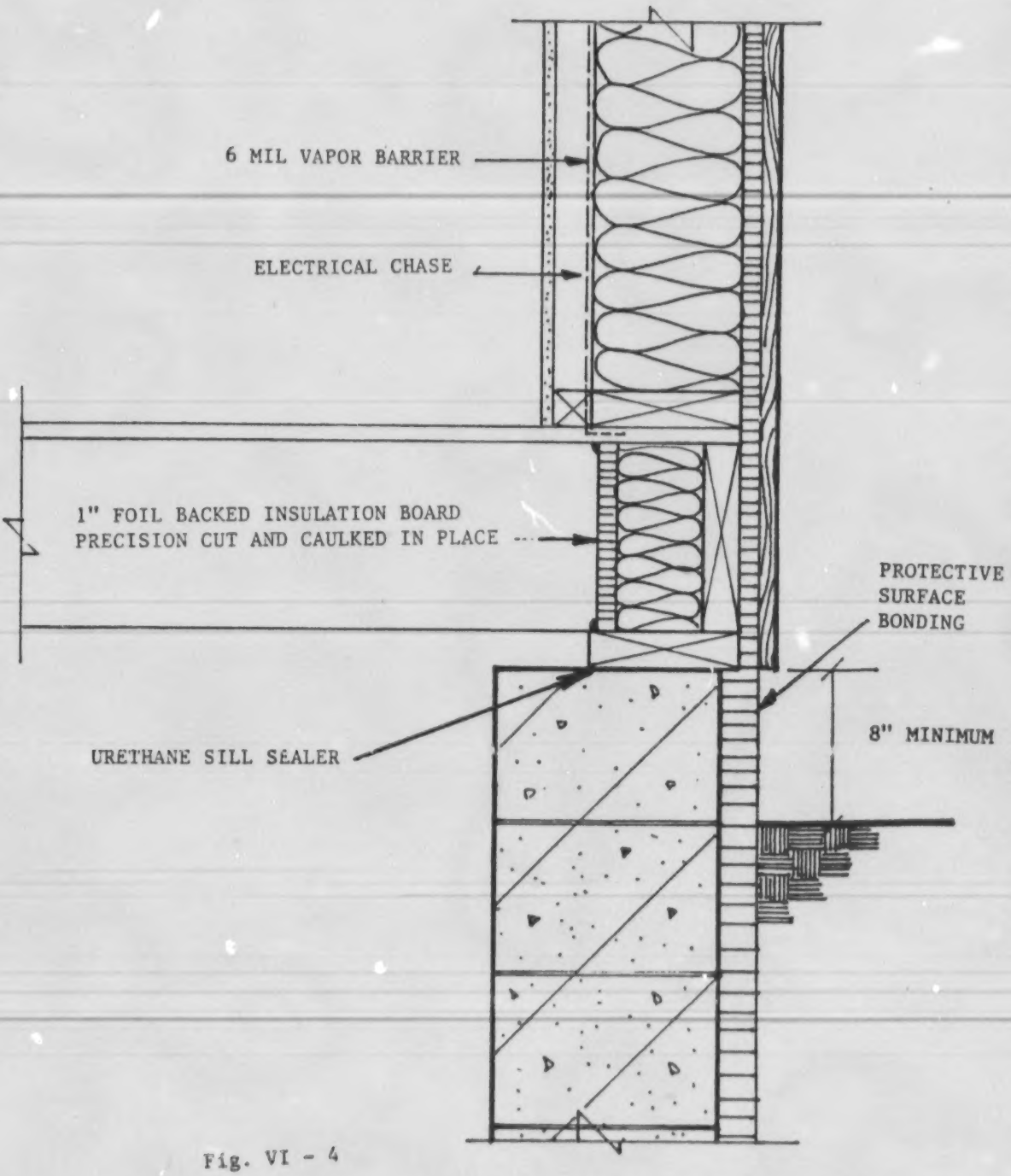

Fig. VI - 4

VAPOR BARRIER TREATMENT
AT RIM JOISTS OR BOX HEADERS

(2) Open crawl spaces foundations must be heavily insulated. (Figure VI-5) Un-insulated floors over unheated basements or crawl spaces create an uncomfortable environment carrying away body heat by convection and radiation. They also waste fuel dollars through excessive heat conduction.

Two insulating techniques exist to insulate crawl spaces. Either insulate the crawl space walls or the floor above the crawl space. The R-values for crawl space floors should equal the above grade wall R-values if the crawl space walls are not insulated. Figure VI-5 shows a compromise version using both techniques. The insulated walls provide a warm crawl space where ducts and piping can be routed without requiring extreme measures for insulating. The insulated exterior wall also provides a good thermal break which keeps the floor warmer.

Vents with insulated weatherstripped covers should be provided to allow ventilation in non-winter months.

Another technique for maintaining warm floors above crawl spaces or un-insulated concrete slab, is the use of a heated floor cavity. For example, a home with an open crawl space, a double floor with a 16-to-48 inch space between floors would provide a convenient area for the installation and servicing of utility runs (e.g., air-to-air heat exchanger). This open wood plenum system is fully described in a booklet from the American Plywood Association. The advantage of insulated warm air plenums is that the furnace or some ventilation fan can be left on in warm months to provide ventilation and eliminate crawl space vents.

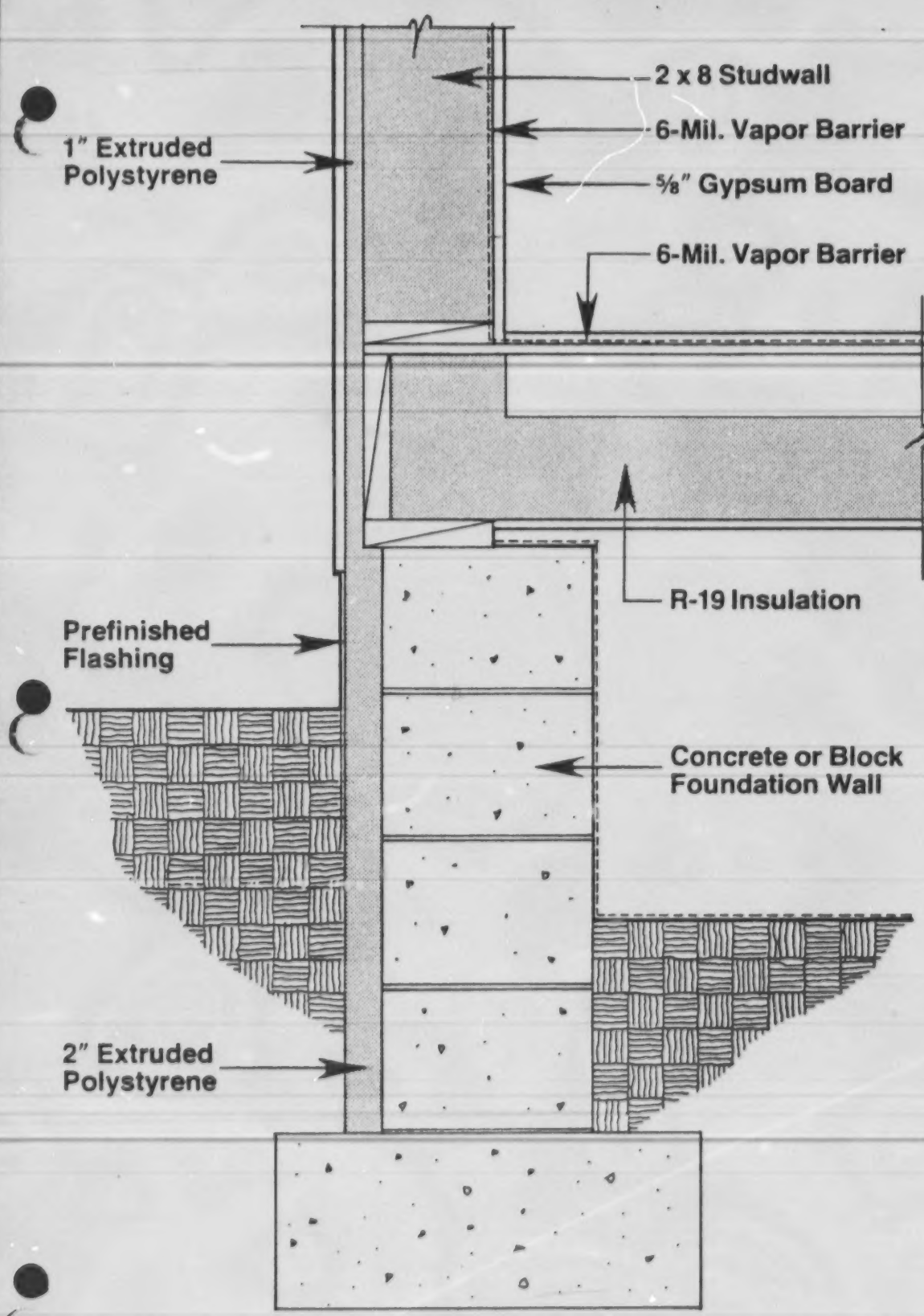

FIGURE VI - 5

CRAWL SPACE FOUNDATION

(3) Slab on grade foundation (Figure VI-6) construction requires the footing walls and floor be heavily insulated. An insulated floor becomes a cold surface carrying heat away from bodies by conduction and radiation. Thus, a cold floor is a source of discomfort and even a health hazard to children who play on it.

Also, stratification of air is a common problem with un-insulated floors. As warm air rises to the ceiling, colder air settles at the floor. In addition to the temperature differentials, condensation can form on the cold floor. Usually this dampness, which causes mildew, is concealed under rugs.

(4) Pressure treated wood foundations are easily insulated. (Figure VI-7 and VI-8). Note the floor truss (rather than solid joists) are shown. The floor truss allows the easy passage of wiring, plumbing, or ducts. It also simplifies the finishing of the basement ceiling. The trusses are also less prone to warping than solid joists. On a cost basis, the floor truss system is generally equivalent to a 2" x 10" beam system. However, costs and availability can vary widely dependent on location.

Many controversial factors surround preserved wood foundations. It has been demonstrated that wood foundations are easier to insulate than masonry. A number of alternative methods exist for the construction of wood foundations. Contact the American Plywood Association for more information.

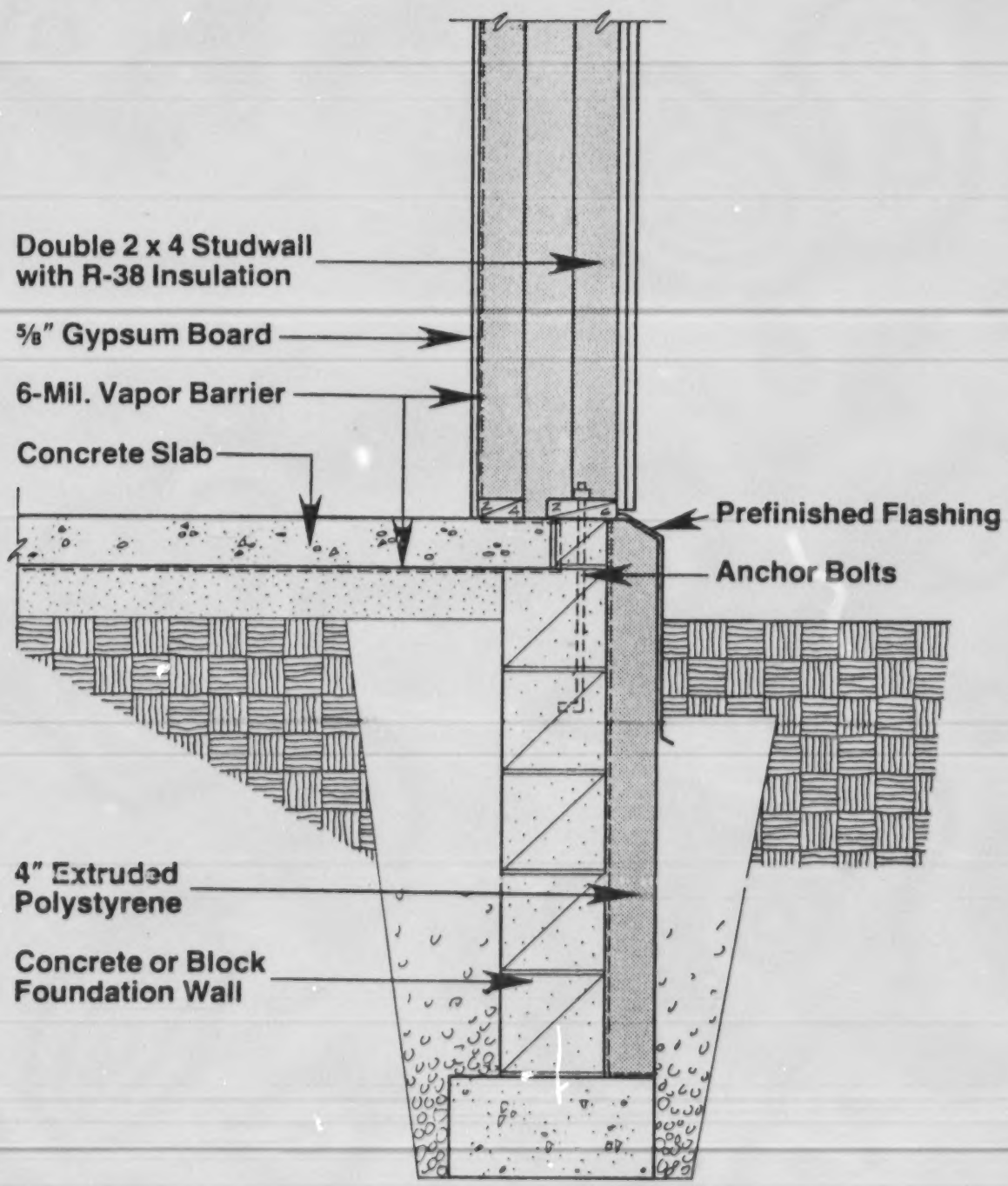

FIGURE VI - 6

SLAB ON GRADE FOUNDATION

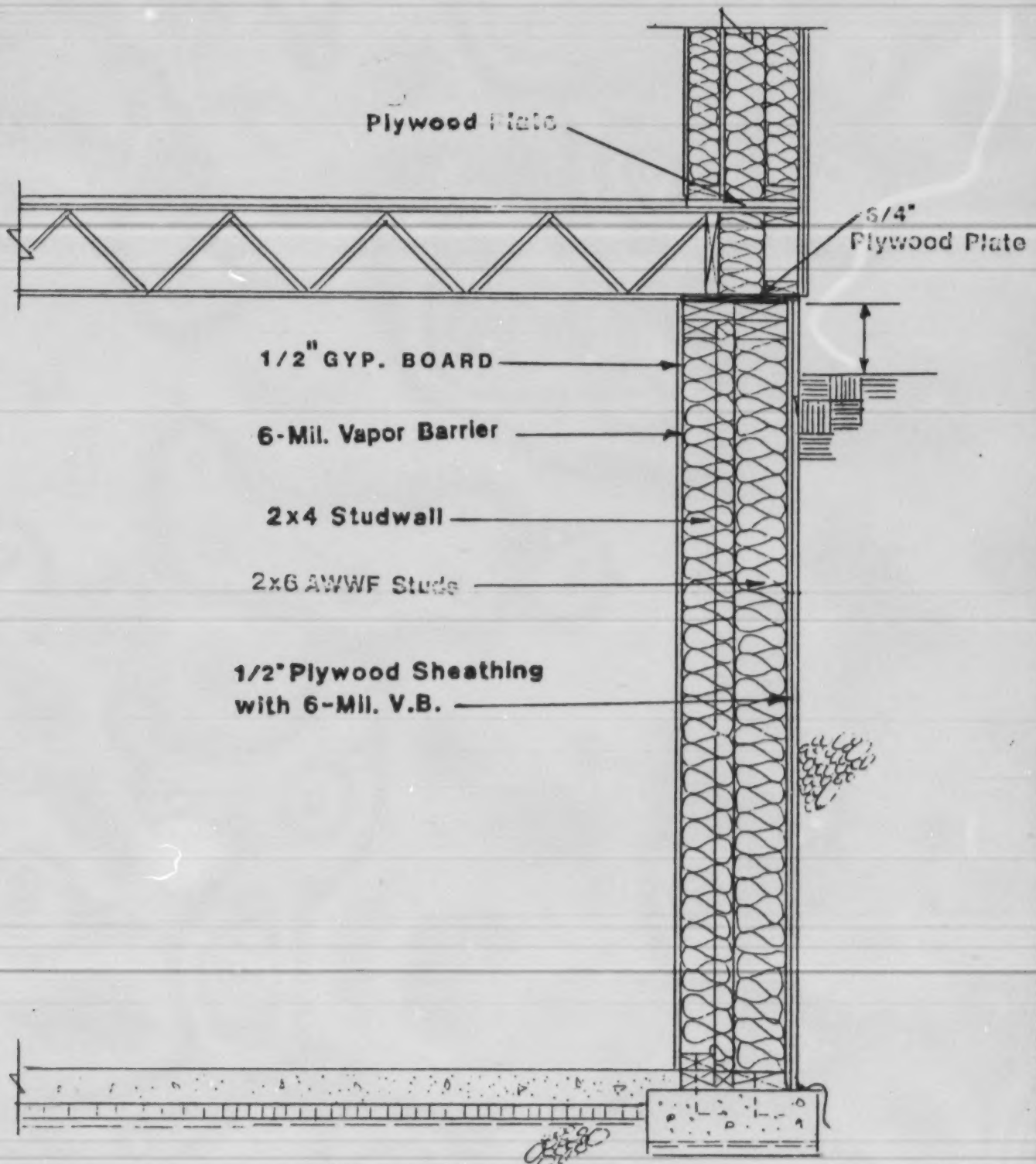

Fig. VI - 7

153

WOOD FOUNDATION WITH FLOOR Truss

VI - 12

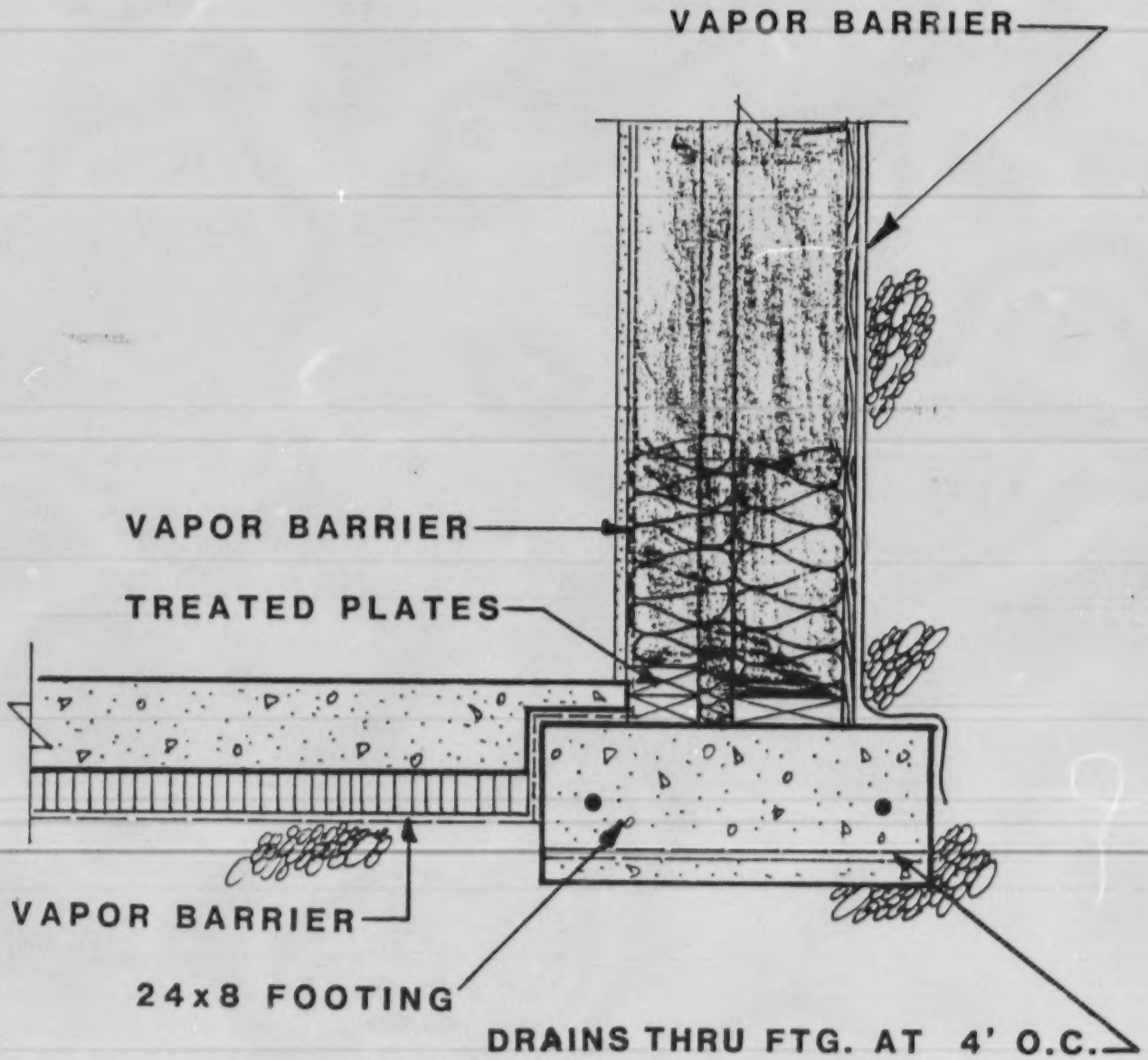

FIGURE VI - 8

CONC. FOOTING DETAIL FOR WOOD FOUNDATION WALL

The final decision on which foundation will be selected is determined by many factors ranging from the availability of materials, to market acceptability.

B. BASEMENT FLOORS

Forty percent of the heat loss for a superinsulated home can be through the un-insulated basement floor. If the floor is to be used as a living area, one to two inches of styrofoam should be placed over a vapor barrier before the slab is poured.

A word of caution, placing the vapor barrier under the slab will delay the concrete set-up time. After the bleed water finally evaporates, the concrete will set-up extremely fast. Thus, a different plasticizer may be required until the concrete tradespeople become more comfortable with the faster set-up time.

If the basement floor is not intended to become living space, the recommendation is not to insulate. The several BTU's per hour per square foot coming from the slab floor can provide nearly a half ton of cooling in summer. Almost enough to keep a superinsulated home cool during the hottest Minnesota summer day.

C. FOUNDATION WALLS: RETROFIT CONSTRUCTION

The easiest method to control foundation heat losses for the super-insulated retrofit is to simply isolate the basement from the rest of the house. Frequently, basements are used only for storage and not as

living space. Thus, the basement could remain unheated with a vapor barrier applied to seal it from the rest of the house like a crawl space. However, most consumers find this alternative unacceptable.

The type of house usually undergoing a superinsulated retrofit probably has a leaky basement. When exposing the exterior wall for waterproofing, several inches of extruded polystyrene should be applied from the footing to the sill plate. To avoid the creation of thermal weak spots, exterior retrofits should be continuous from the foundation footings to the roof. Exterior application also eliminates the need for interior framing. Another exterior retrofit alternative used by some builders can reduce excavation. In dry, well drained soils, rigid insulation board is placed several feet below grade and then outwards from the wall almost horizontally. However, this technique is not particularly effective in heavy, wet soils, where heat flows are almost horizontal.

The exterior retrofit can also protect the existing wall from potential structural damage. In most homes with un-insulated walls, enough heat loss escapes through the basement walls and basement floor to prevent freezing of the earth surrounding the basement. If this thermal blanket is eliminated by insulation, frost heave and structural damage can result. The frost heave problem can be minimized by using gravel or sand for the backfill, if soils are not properly drained.

The recommendation to insulate to the exterior of the foundation wall may be too expensive to be practical in some cases. Retrofit to

the interior is an alternative, if the basement is nice and dry. A new wall can be framed and set in place. The procedure would be similar to above grade walls except the bottom plate must be protected from moisture. This can be done by either using treated wood or redwood bottom plate. Also extensive detailed vapor barrier application is required to seal the large number of utility runs in a conventional basement.

D. FOUNDATION FLOORS: RETROFIT

Pouring a new insulated slab floor is one alternative, since the condition of most homes undergoing extensive superinsulated renovation requires a new floor. Another alternative is to mechanically set pressure treated sleepers over the existing coment floor and insulate with some moisture resistant form of insulation, like vermiculite or styrofoam. Be sure raising the basement floor will still leave sufficient head room. Then, apply the continuous vapor barrier and foundation plywood. Either alternative should substantially reduce the wicking of humidity through the basement floor from the ground soils. (Figure VI-9 and VI-10)

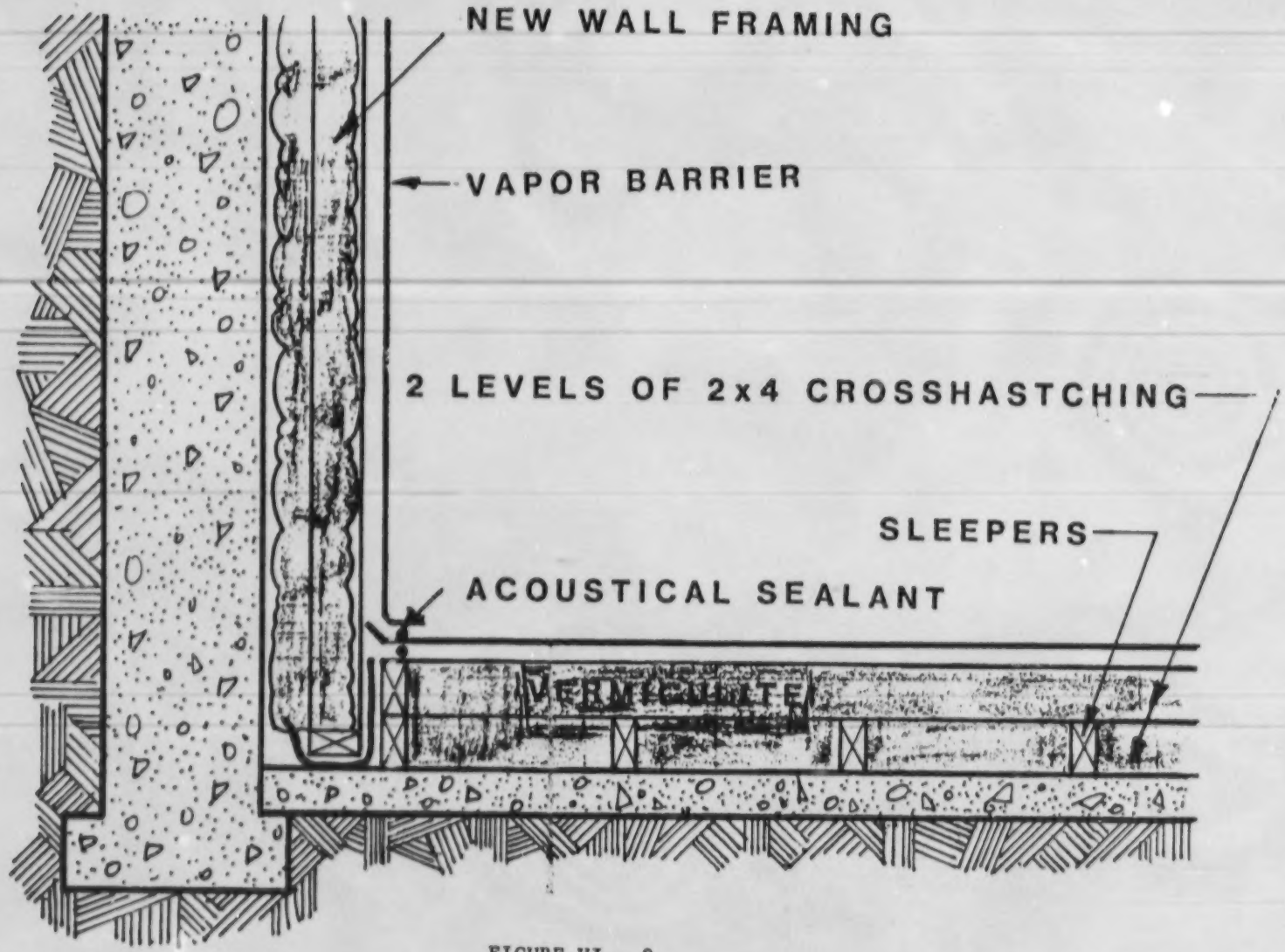

FIGURE VI - 9

RETROFIT BASEMENT WALL W/ DOUBLE CROSSHATCHED FLOOR

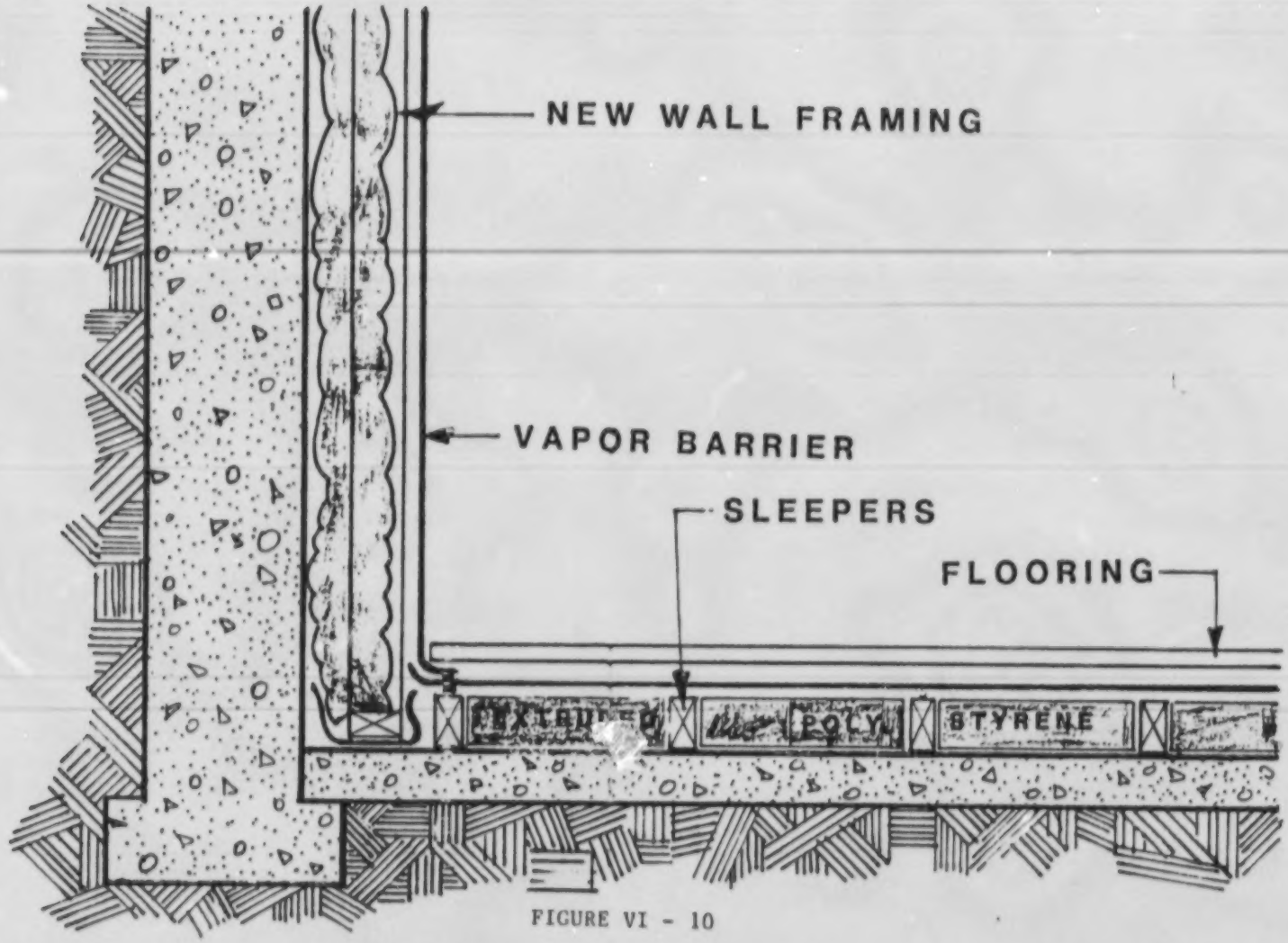

FIGURE VI - 10

RETROFIT BASEMENT WALL AND FLOOR

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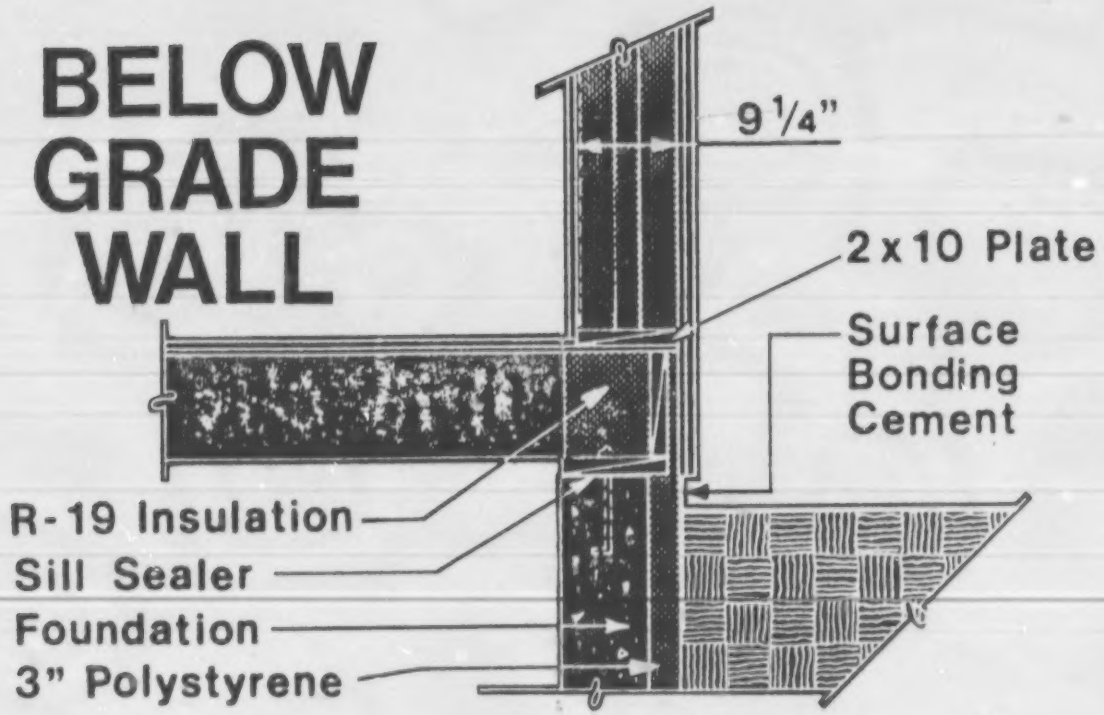
Richard Hand (Anoka, MN) Hand House, Hand Construction, Anoka, MN.
James Martin (Minneapolis, MN), Solar Saltbox, P & M Construction, Northfield, MN.

XI-12

BELOW GRADE WALL



SUPERINSULATION LTD.

VII. WINDOWS

TABLE OF CONTENTS

	PAGE
A. WINDOW CRITERIA	3
B. BIBLIOGRAPHY	8
C. WINDOW TREATMENTS	9

SUPER INSULATION MEANS:

- 10-14% glass area to floor area
- 70% of glass area facing south
- 30% of glass area facing nonsouth

OR

SOUTH WINDOWS

- 6-10% Glass area to floor area

Other Windows

- %–4% Glass area to floor area

--INTRODUCTION--

Windows can be a major source of heat loss in the superinsulated home where the vapor barrier and extra insulation have been carefully installed. However, solar gains through the south facing windows of a superinsulated home may more than compensate for those heat losses. Typically, south facing windows can provide a third or more of the energy needed for winter heating. (In ordinary houses, south facing windows do not reduce fuel bills by more than five (5) percent).

Superinsulation provides a great deal of design flexibility for the location of window glazing. In contrast with the design characteristics of typical solar passive design, a superinsulated home can take advantage of non-south views, allow for natural summer ventilation, and satisfy building codes without sacrificing energy efficiency.

The south facing windows (e.g., 8% glass to floor area) and thermal mass (10 to 20 tons) in a superinsulated home is sufficient to provide for the moderate amounts of passive solar gain. In fact, south facing windows and additional mass is neither energy effective nor cost effective.

--INTRODUCTION--

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A. WINDOW CRITERIA

Windows in the superinsulated house follow common sense criteria.

(1) South Windows are large enough to admit sunshine, but not so large as to become a major source of heat loss during cold winter nights, or heat gain on hot summer days. Typically, the ratio between south facing windows and floor area should be between 6% to 10%. (Figure VII-1 illustrates window overhang sizing for seasonal window shading.)

(2) Other Windows should be kept to a minimum (approximately 4% window area to floor area facing non-south), However, windows should be located to meet local code and personal aesthetic requirements.

(3) Orientation of windows is not important as frequently stated. In the Twin Cities, for example, house orientation can be 20° from due south without reducing solar gain. If house orientation were 45° from due south, solar gain would be reduced 10%. This would increase the fuel consumption less than 5 gallons of fuel oil, during the winter. Using common sense is important. If possible, locate 70% of the glass area south and the remaining 30% around the other walls. Remember, superinsulated house design is very forgiving. Superinsulation means flexibility.

Flexibility for window orientation is also possible for retrofits. Since superinulated retrofits are only one part of a major renovation with the walls being rebuilt, new south facing windows can be added while also building over and eliminating non-south window area.

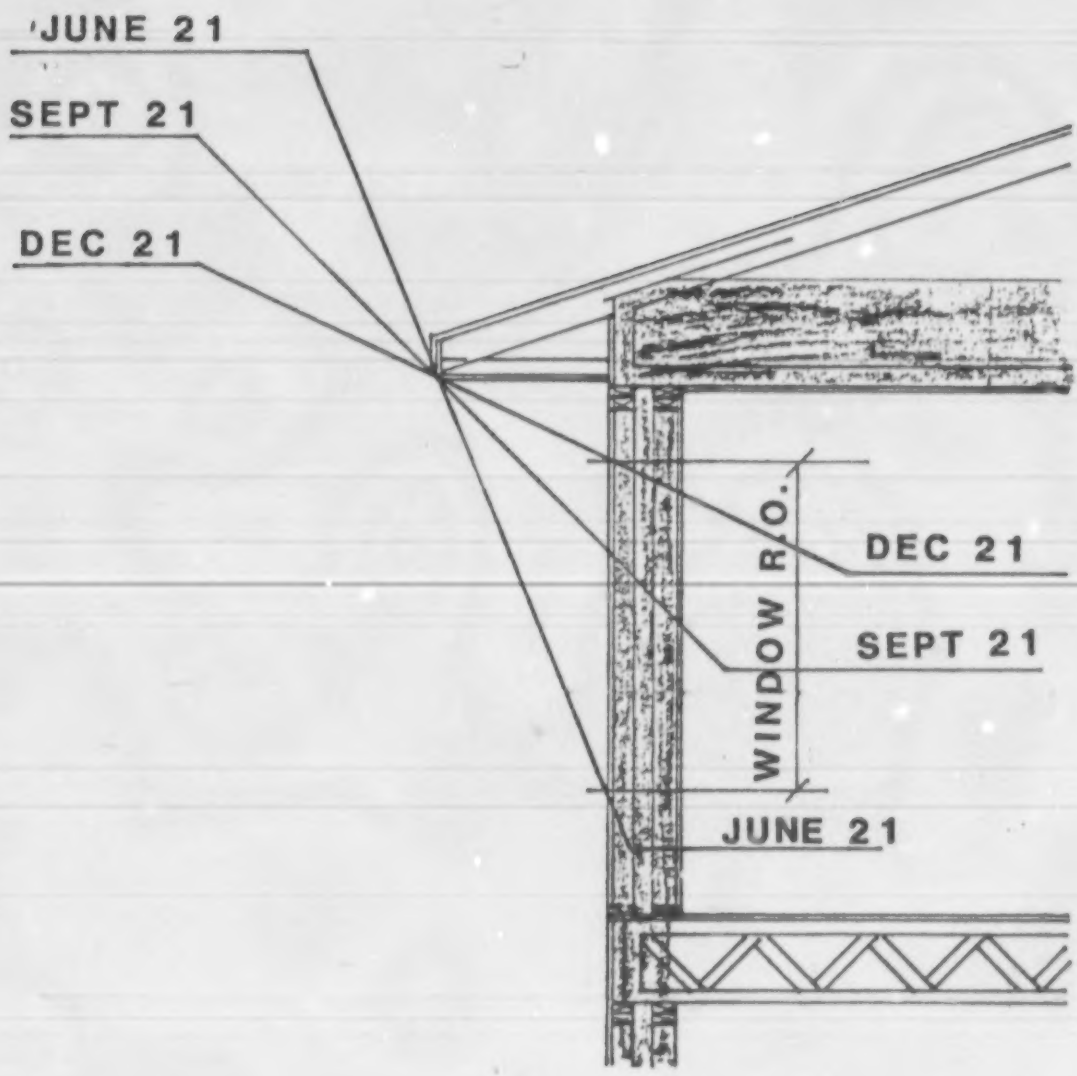

FIGURE VII-1

OVERHANG SIZING FOR WINDOW PLACEMENT

(4) Window Glazing should be at least double to the south, although triple is a better investment. Three to four glazings in all other directions should be used. Again, look at the Robinson Rules-of-Thumb to balance window glazings with other house component R-values. (Figure VII-2 shows one technique to avoid winter condensation problems for single and double glazed windows.)

ROBINSON RULES-OF-THUMB

SURFACE[1]	WINDOWS	OPEN ATTIC (Cellulose)	FRAME WALLS (Fiberglass)	BASEMENT WALL Polystyrene	BASEMENT Floor
Cost ($/ft^2-R)	5.00	.015	.045	.075	
R VALUES	1	18	11	8	4
	2	37	21	16	7
	3	55	32	24	11
	4	73	42	33	15

Scaling Factor below grade wall by .75
below grade floor by .35

(5) Window type is also important. Typically, most homes have many more operable windows than necessary for adequate ventilation. Windows that are fixed and sealed in place are the most energy and cost efficient. Yet there is still a need for some operable windows for ventilation, to satisfy code requirements and to permit escape in case of fire. Of the operable windows, casement windows are preferred over double hung, or sliders.

---

[1] All surfaces above grade (i.e., experience the same number of degree days).

(6) Window Insulation Systems are frequently identified as the method to reduce night heat losses through windows. Windows using shutters deployed during the night are claimed to substantially reduce overall window heat losses while maintaining solar gains captured during the day. At present, numerous insulating window treatments have been developed. However, existing information indicates most window systems are not energy or economically efficient.

The insulating performance of window insulating systems has been far less than the specified design values. Also, the economic performance of most window insulating systems have been poor. Typical installed cost ranges between $\$4.00/ft^2$ and $\$15.00/ft^2$. If a 100% efficient R-8 window system were religiously operated day and night, and cost $\$4.00/ft^2$ it would have a 9 to 10 year pay back. A 100% effective R-4 window treatment would have a 12 year pay back.

In general, those wanting a zero energy house and who are willing to maintain the day/night discipline necessary for efficient operation, site-built exterior shutters are the most likely solution. In addition to insulating, if designed correctly, window treatments can also provide privacy, security, and be decorative.

(7) Absorptive or reflective films are applied to windows to reduce the amount of radiant heat and glare from the sun, and also to reduce room heat loss. Generally, the reduction of winter heat loss is equivalent to the addition of a storm window. The films can be either

applied directly to the window, or to the outdoor facing side of a window shade. The control of radiant energy by reflective films either entering into or escaping from the room can increase overall comfort. In addition, these films eliminate most of the sun's detrimental ultraviolet rays, one of the major causes of color fading and finish cracking.

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Personal Communication with:
Jerry Wolf, Research Director of Anderson Window
Robert Besant, University of Saskatchewan
Dan Hagen, Brookhaven National Laboratory

C. WINDOW TREATMENTS

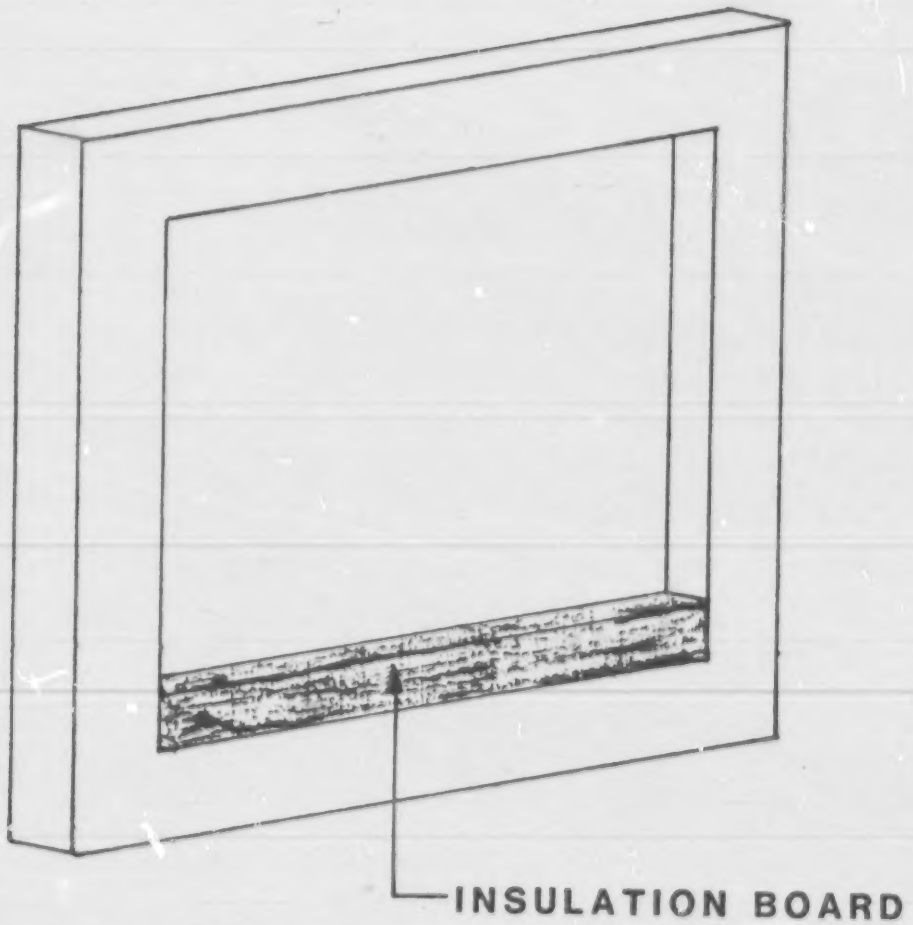
(1) Interior window treatments range from thermal shades and insulating curtains to various forms of hinged or pop-in shutters. Most systems have failed to maintain a tight edge seal. The result is a problem of excessive water vapor condensation and frosting on the window's surface. Conditioned inside air simply passes the edge seal and comes into contact with the low temperature glass. The result is frequently water damage to the window, and it dramatically increases the heat loss. To work effectively, an interior window treatment needs a costly refrigerator-like magnetic gasket seal.

Interior window treatments should not be used on south-facing windows. Shutters on south facing windows can form very elementary, but effective, solar collectors if not opened in the day time. If the window treatment is allowed to function as a solar collector, the heat build-up could result in the window delaminating and warping or even breaking.

(2) Exterior window treatments do not create the water vapor condensation problems common to interior insulating systems. Historically, exterior shutters have been used to protect fragile window glass from the elements. These treatments can be fitted to reduce heat loss on cold winter nights.

Special care must be taken to make sure exterior insulation systems are strong enough to avoid weathering and damage from the elements.

Also, an interior operating device eliminates the need for the homeowner to go outside to manually install the window treatment. However, either window system re-enforcement or interior operating systems increase costs.



TECHNIQUE TO AVOID WINDOW CONDENSATION PROBLEMS

FIGURE VII-2

Comment: Insulation board on the bottom part of outside of a single or double glazed window will keep the interior glass warm at the bottom and reduce condensation dripping on the window sill.

VIII. ENTRANCES

TABLE OF CONTENTS

		PAGE
A.	DOORS	1
B.	AIR-LOCK ENTRIES	1
C.	BIBLIOGRAPHY	4

A. DOORS

All exterior doors should be of the steel foam core type. Typically, these doors have magnetic seals and are almost air-tight. The insulated steel door eliminates problems common to the wood frame door, such as: warpage, shrinkage, swelling, etc. The foam core provides an R-8 to R-15 compared to the R-2 wood door. The insulated doors cost about $25 more than a wood door, but pays for itself in less than one heating season.

Door installation for new construction is generally straight forward, since the doors are pre-hung. For retrofit, the existing framing or stud opening should be altered to allow for installation. In both cases, vapor barrier application is similiar to that for windows. Insulating foam around the door jamb is another alternative to form an airtight seal.

Another alternative for retrofits is weatherizing the existing door and building an entrance hallway or air lock incorporating the insulating door. The vapor barrier must be placed on the warm side.

B. AIR-LOCK ENTRIES

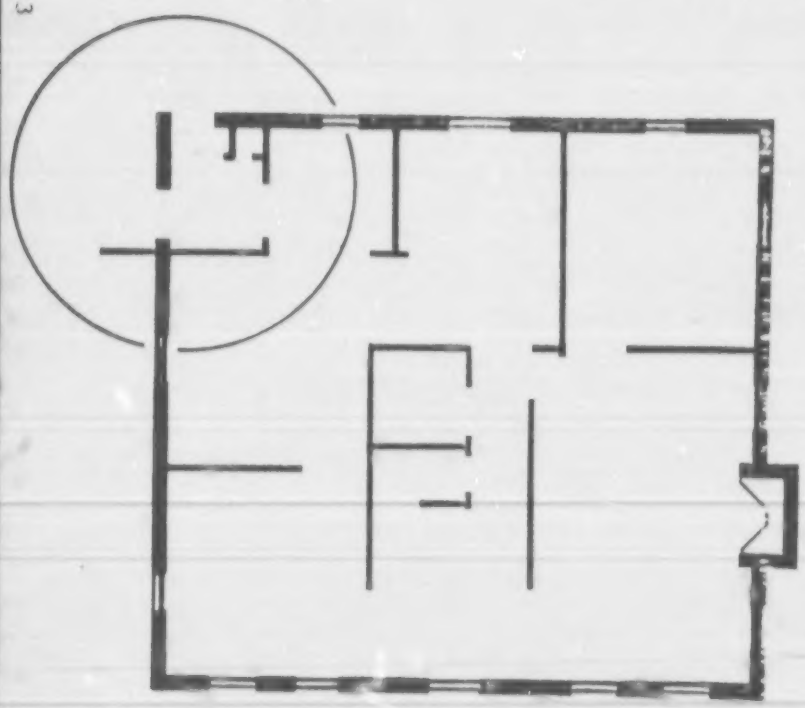
Air-lock entries or vestibules (Figure VIII-1) prevent blasts of cold air from entering the conditioned living space. Air locks add little to the house cost ($300 to $800) and also are typically large enough

to serve some functions including closets, mudrooms, etc.

Frequently air-lock entries are incorporated into superinsulated homes. However, in an air tight home, air locks cannot be justified on the basis of reduced fuel bills. If an air-lock entry can be easily integrated into the house design and serve a function beyond saving energy it is worth while. Again, superinsulation construction requires the builder to use common sense.

Air-Lock Entries

Interior



Exterior

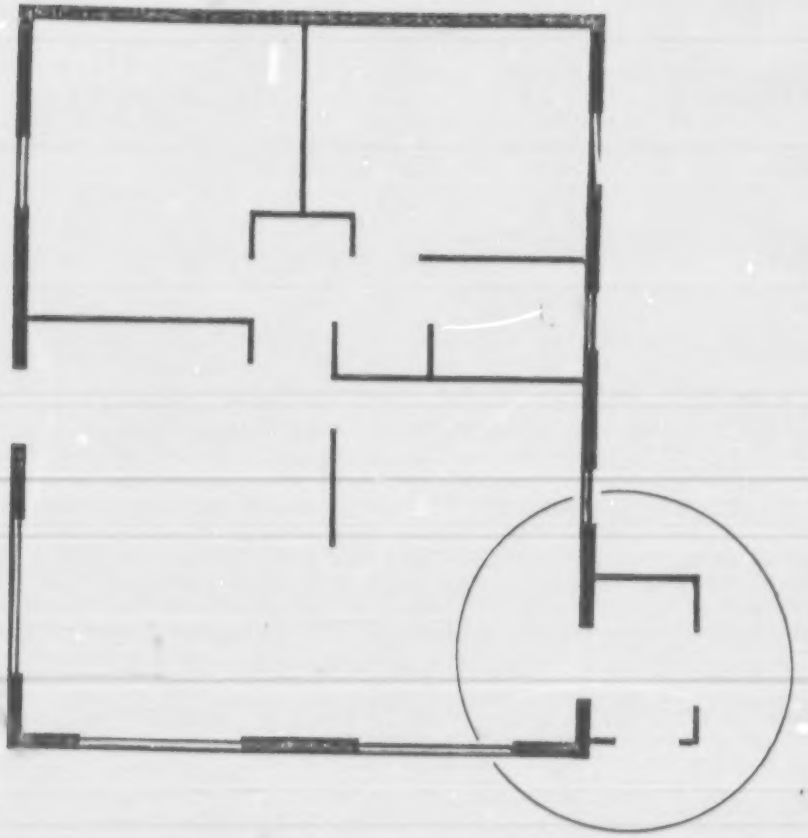


FIGURE #III - 1

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IX. INDOOR AIR POLLUTION IN SUPERINSULATED HOMES

TABLE OF CONTENTS

		PAGE
A.	CLASSES OF POLLUTANTS	2
B.	IMPACT OF ENERGY EFFICIENT/SOLAR DESIGN ON INDOOR AIR QUALITY	2
C.	HEALTH EFFECTS OF ELEVATED INDOOR-GENERATED POLLUTANTS	5
D.	CONTROL STRATEGIES	7
E.	CONCLUSION	10
F.	REFERENCES	13

--INTRODUCTION--

A wide range of alternative solar/energy efficient housing alternatives have been designed as to the growing concern over the availability and price of conventional energy sources. Proposed solutions for residential structures range from new forms of energy production to very intense energy conservation (i.e., super-insulation). However, each new energy system introduced into the indoor residential environment has the potential to alter indoor air quality.

The air infiltration rates for current ("state-of-the-art") super-insulated low energy homes range from 0.05 to 0.25 air changes per hour (ACH), compared with 0.8 to 1.0 ACH for conventionally constructed residential buildings. There has been concern that tightly constructed, heavily insulated homes are so well sealed that the quality of the indoor air poses a health hazard. The potential sources of indoor air pollution come from both inside and outside. Air quality in many major cities is not always pollutant free. To assume humans require high air infiltration to flush out indoor air pollutants ignores this fact. Houses can give shelter from some outdoor sources of pollutants, so real benefits can stem from building homes with low air infiltration rates. Numerous studies are presently being conducted on the subject of indoor air pollution in Europe and the United States. Through the use of scientific measurements and analysis methods, those energy innovations compatible with the maintenance

of a healthy indoor environment are being identified.

Currently no guidelines exist for indoor air quality standards similar to the ones established for ambient air quality. Also, application of ambient air quality standards for indoor air is not applicable because of the large amount of time spent indoors (70 percent) and the variability of pollutants which can emanate from indoor sources.

A. CLASSES OF POLLUTANTS

There are three major source classes of indoor air pollution: 1) outdoor generated pollutants entering the indoor environment through infiltration; 2) indoor-generated pollutants, the primary sources being combustion (carbon oxides, nitrogen oxides, particulates); and, 3) indoor-generated pollutants with the primary source being human activities (carbon dioxide, hydrocarbons, particulates) and building contents or materials (formaldehyde, radon, asbestos).

B. IMPACT OF ENERGY EFFICIENT/SOLAR DESIGN ON INDOOR AIR QUALITY

Conditions influencing indoor air quality for energy efficient homes would be: 1) reduced infiltration and ventilation (about 0.75 air changes per hour (ACH) or less); 2) different quantities and ratios of building material (thermal mass, concrete, cement

blocks, tile floors, bricks, etc.); 3) addition of sunspace or greenhouse to living space; 5) increased sunlight in living space; 5) increased use of wood combustion systems; and, 6) increased exposure of living space to soil (e.g., berming).

Reduced ambient infiltration actually shields indoor spaces from outdoor generated pollutants.

The other two classes of indoor-generated pollutants, however, could impose health risks to the occupants. Major combustion pollutants (carbon monoxide, nitrogen oxides, particulates, and hydrocarbons, particularly aldehydes) because of additional wood combustion, or fossil fuel (especially gas) combustion for heating or cooking operations as well as tobacco smoke with reduced ventilation could increase to a significant level. Indoor pollutants from building materials would also be increased due to extensive use of radon-emitting materials for thermal mass (e.g., concrete, bricks, tile). Further, with the addition of greenhouse space, more pollutants may be released into the living space environment, (e.g., hydrocarbons from insecticides and cleaning supplies, radon from soil).

Also, with additional sunlight, increased pollutant levels or humidity could influence photochemical oxidation and conversion of indoor air pollutants to other health-risk products.

All of these pollutants may rise to significant levels due to energy conservation in the form of reduced infiltration.

Actual measurement data on indoor air pollutant concentrations in buildings with alternative energy systems is minimal. Hollowell, et al,[1] have measured pollutants from gas stove emissions in buildings with reduced ventilation (0.2-0.3 ACH). These investigations indicated significant levels of carbon monoxide (CO), nitrogen oxides (NO/NO_2), respirable aerosols, particulate sulfur, nitrogen and carbon compounds with infiltration of less than one air change per hour. In a public building with no indoor-generated combustion sources, the research team reported no significant increase in indoor pollution levels with reduced ventilation rate. The exception was CO_2 from human metabolic activity, which was still far below levels considered a health hazard. In fact, the air quality improved for outdoor generated sources of nitrogen dioxide (NO_2) and ozone (O_3)[2].

Pollutants emanating from building materials in relationship to reduced ventilation were also investigated by this group. The results indicated increased radon and radon daughter levels[2,3] and formaldehyde levels[2] with reduced ventilation. Studies on levels of hydrocarbons or other pollutants or studies on generation of secondary pollutants through decay or photochemical oxidation have not been conducted. Literature on the impact of alternative energy systems components on the indoor environment is rare. One investigation has cited the ambient environmental

impact of alternative energy sources[4]. Another investigator indicated data where infiltration effects overwhelmed radon emission levels from granite rock storage[5].

C. HEALTH EFFECTS OF ELEVATED INDOOR-GENERATED POLLUTANTS

Pollutants generated from the combustion of fossil fuels, wood, or tobacco have implications for adverse health risks. Elevated nitrogen dioxide levels have been correlated with acute and chronic respiratory diseases as well as possible increased mortality from cardiovascular diseases and cancer. The possible conversion products formed from catalytic oxidation (nitrates, nitric acid, ammonium, nitrosamine, and organic nitrogen compounds of amino and pyridino type) are implicated in respiratory disease and are suspected carcinogens. The health effects of carbon monoxide from fossil fuels, gas, wood, and tobacco combustion are well known: 1) acutely elevated levels cause nausea, vomiting, asphyxiation, coma, and death; and 2) low levels cause headache and dizziness.

Particulate matter in various forms from fossil fuel, wood, and tobacco combustion are a complicated class of pollutants. They cause adverse health effects alone or through interaction with other pollutants e.g., the interaction of sulfur dioxide (SO_2) and elevated particulate levels has been well documented. The wide spectrum of adverse health effects from this variant group

range from respiratory disease to cardiovascular disease and cancer.

The major pollutants emitted from building materials also are a potential health risk. The adverse health effects of radon from concrete blocks, soil, groundwater, particleboard, etc. are increased risk of lung and other cancers. Health effects of chronic exposure to asbestos released from insulatior range from asbestosis to bronchogenic carcinoma to neoplasms. Acute asbestos exposure can cause plural or peritoneal mesothelioma 15 or more years after exposure. Formaldehyde emanating from wallboard or insulation, and tobacco smoke in low levels cause eye, nose, and upper respiratory tract irritation while acute high level exposure causes deeper respiratory irritation. Other chronic exposure-related health risks are not known. Other major sources of indoor generated pollutants may also pose potential health risks. Exposure to excessive hydrocarbon levels from cooking, pesticides in greenhouses, cleaning supplies, spray can propellants, wood combustion etc., can, in general depress the central nervous system. The extensive variety of these hydrocarbons causes a varied spectrum of health effects including impacts on the respiratory, cardiovascular, and clearance systems. Elevated chronic carbon dioxide exposure from human metabolism could change the acid base balance of the human system upon which all metabolic activity is based.

The health effect of conversion products from photochemical

oxidation, increased pollutant levels or humidity are varied. The health effects range from irritation to involvement of the respiratory and cardiovascular systems and cancer.

D. CONTROL STRATEGIES

The control of gaseous combustion generated pollutants can be accomplished several ways: 1) source removal (e.g., using electric cooking appliances, prohibiting tobacco smoking, eliminating wood combustion); 2) source ventilation (e.g., appliance ventilation, adequate fireplace and woodstove ventilation systems); 3) air-to-air heat exchangers to provide ventilation but minimize heat loss; and 4) absorption by activated carbon filter systems.

Control methods employed to control combustion generated gaseous pollutants are also applicable for combustion-generated particulate pollutants. However, air-to-air heat exchangers are only partially effective. Absorption by activated carbon is not applicable to particulate pollutants. Effective controls include the employment of inert filter devices and electrostatic precipitators which remove particulates.

The control of pollutants emanating from building materials includes: 1) material substitution (i.e., prohibit the use of building materials with excessive emissions of formaldehyde, asbestos, or radon); 2) sealants and barriers (i.e., seal the

asbestos from releasing fibers, use polyethylene sheets or epoxy paints to seal materials from radon outgassing); 3) air-to-air heat exchangers (i.e., reduce formaldehyde and radon by ventilation with minimal heat loss); 4) absorption by activated carbon (e.g., radon and formaldehyde) or absorptive environmental surfaces (e.g., formaldehyde by special surfaces); 5) electrostatic precipitators with high voltage remove radon and radon daughters.

The control of human activity related pollutants (hydrocarbons or carbon dioxide would be obtained by 1) source removal (e.g., prudent use of cleaners, pesticides, spray can propellants, reduction of tobacco smoking); 2) source ventilation requiring use of the product only in adequately ventilated areas; 3) maintenance of general ventilation with minimal heat loss by use of air-to-air heat exchangers (e.g., carbon dioxide and general hydrocarbon removal); and 4) absorption by activated carbon (e.g., hydrocarbon emission).

TABL.

INDOOR POLLUTANT CHARACTERISTICS, IMPACTS, AND CONTROLS

POLLUTANT	MAJOR SOURCES	FORM	EXPOSURE LEVELS INDOORS	HEALTH IMPACTS	EXAMPLE CONTROL STRATEGIES
Sulfur Dioxide	Ambient Air Indoor: fossil fuel combustion	Gas	Ambient source: significantly lower than outdoors	Risk of acute and long-term respiratory effects in conjunction with particulates/conversion products--respiratory effects, heart disease, neoplasms	Absorptive surfaces, source ventilation, ventilation
Nitrogen Oxides	Ambient air, vehicle emission Indoor combustion: carbonaceous fuels (gas stoves and heating, wood and tobacco combustion	Gas	Ambient source: lower or approx. same as ambient levels. Indoor source: significant levels with unvented combustion	Risk of acute respiratory effects, chronic respiratory effects, possible increased mortality from cardiovascular disease and cancer/Conversion products: respiratory effects and suspected carcinogens	Source removal, source ventilation. Absorption by activated carbon, ventilation
Carbon Oxides	Ambient air, vehicle emission Indoor combustion; carbonaceous fuels, (woodstoves, tobacco) infiltration from garage Metabolic activity	Gas	Ambient source: approximates patterns of outdoor levels Indoor source: significant levels with unvented combustion Indoor Source: not significant acute exposures. Elevated chronic exposures:	Lower concentrations: headache dizziness. Higher concentrations: nausea vomiting, asphyxiation, death Chronic levels: change acid base balance	Source removal, source ventilation, ventilation, catalytic oxidation, complete combustion. Ventilation
Photochemical Oxidants	Ambient air		Ambient source: significantly lower than outdoors	Eye irritation, respiratory discomfort, chronic exposure not understood.	Absorptive surfaces, ventilation
Particulates	Ambient air Indoor combustion: (gas stoves, wood and tobacco combustion, heating sources) resuspension from physical activity	Particulate	Ambient sources: lower than outdoors. Indoor source: significant levels from indoor generation.	Varied: range from respiratory to cardiovascular disease and cancer	Source removal, source ventilation filters, electrostatic precipitators, ventilation
Asbestos	Insulation or decorative sprays	Particulate fiber	Indoor source: variable significance of levels unknown	Asbestosis to bronchogenic carcinoma to neoplasms (complicated by cigarette smokers) Risk of acute exposures: pleural or peritoneal mesothelioma 15 years later.	Source removal, material substitution or sealing.
Hydrocarbons	Ambient Air Indoor combustion: carbonaceous levels, (cooking, wood and tobacco combustion) pesticides, spray propellants, cleaning solvents	Gas	Ambient source: approximates outdoor levels Indoor generation: acute exposure can be extremely high, chronic exposure also noted	Risk of a variety of severe acute and long term effects including depression of central nervous system	Source removal, source ventilation absorption by activated
Formaldehyde	Building materials, wallboard, insulation tobacco smoke	Gas	Indoor source: can be significant depending on building materials	Low levels: eye, nose and upper respiratory tract irritation High levels: deeper respiratory irritation	Source removal material substitution, activated carbon absorption, ventilation, absorption by special surfaces, oxidation.
Radon	Surrounding soil & fill Building materials-bricks, concrete, stone.	Gas & Particulate	Significantly higher than outdoor levels dependent on ventilation levels	Enhanced risk of lung and other cancers	Radon gas - activated carbon absorption, ventilation Radon daughters - electrostatic precipitators (ESP), filters, ventilation, radon gas barriers (polyethylene sheets, epoxy paints, etc.)

E. CONCLUSION

The quality of indoor air is determined by the pollutants generated indoors from combustion, building contents or materials, human activities and those pollutants' secondary conversion products. The indoor environment is actually shielded from outdoor pollutant infiltration by reduced infiltration.

Employment of alternative energy practices could increase levels of indoor generated pollutants due to reduced ventilation, different quantities and ratios of pollutant-emanating building materials or different human activities.

In general, a superinsulated home has most of the pollutant control measures already incorporated into the basic design. Carbon monoxide and oxides of nitrogen and sulfur are identified as sources of health problems. However, a superinsulated home almost always incorporates electric cooking and heating. If a combustion furnace is used, it is closed-looped. Combustion furnaces and appliances are seldom used in superinsulated homes because most easily available current gas or oil furnaces are too large to operate efficiently in the very energy efficient, super-insulated home. Thus, it is difficult to attribute oxide health problems to superinsulated homes. However, it is true that any house (superinsulated or not) with unvented gas cooking can have significant oxide levels which could pose potential health problems.

In those homes adding additional glass area for a sunspace or increased sunlight beyond superinsulation design criteria a potential exists for photochemical oxidation. The additional humidity and sunlight could convert several indoor air pollutants (e.g., sulfur oxides) to other health risk products (e.g., sulfuric acid mists).

Radioactive radon gas is frequently identified health problem of superinsulated homes because of the low ventilation rates. However, radon is also a problem in any house having significant amounts of radon producing materials like masonry (e.g., trombe) walls, floors, etc., or where vapor barriers are not used to shield the outgassing of radon from soils or ground water (the prime sources of radon). In a superinsulated house great care is exercised to provide a continuous vapor barrier which blocks the outgassing of radon from the soils through the foundation. Since added masonry or mass is not necessary for thermal storage in superinsulated homes, radon from added mass is avoided. Radon does not pose a health problem in sell-sealed, mechanically ventilated houses. In fact, indoor air quality in recent studies monitoring superinsulated homes reveal lower levels of radon then conventional houses.[7]

Finally, the frequently stated health problems "with humidity and odors" are easily handled with the air-to-air heat exchanger.

Health problems associated with a tightly sealed home are far fewer and easily handled with proper building material selection and air-to-air heat exchangers. While there appears to be an ample number of control strategies and method, little is known concerning the proper application of the control measures. Much more research is required to identify the potentially hazardous pollutants and their exposure levels (i.e., concentrations and duration) which could potentially cause health risks in the alternative energy systems.

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HUMIDITY

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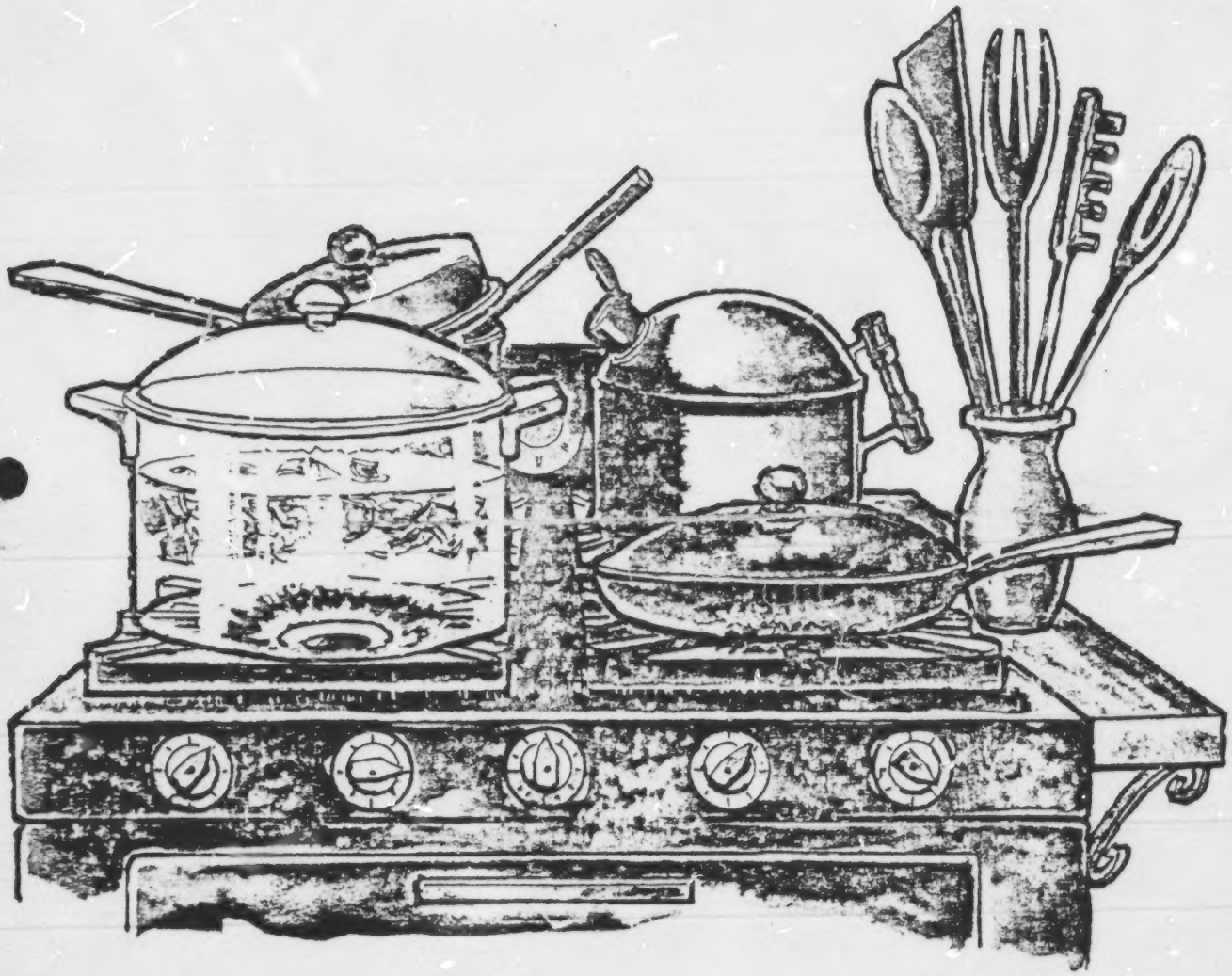
GAS COOKING



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SMOKING

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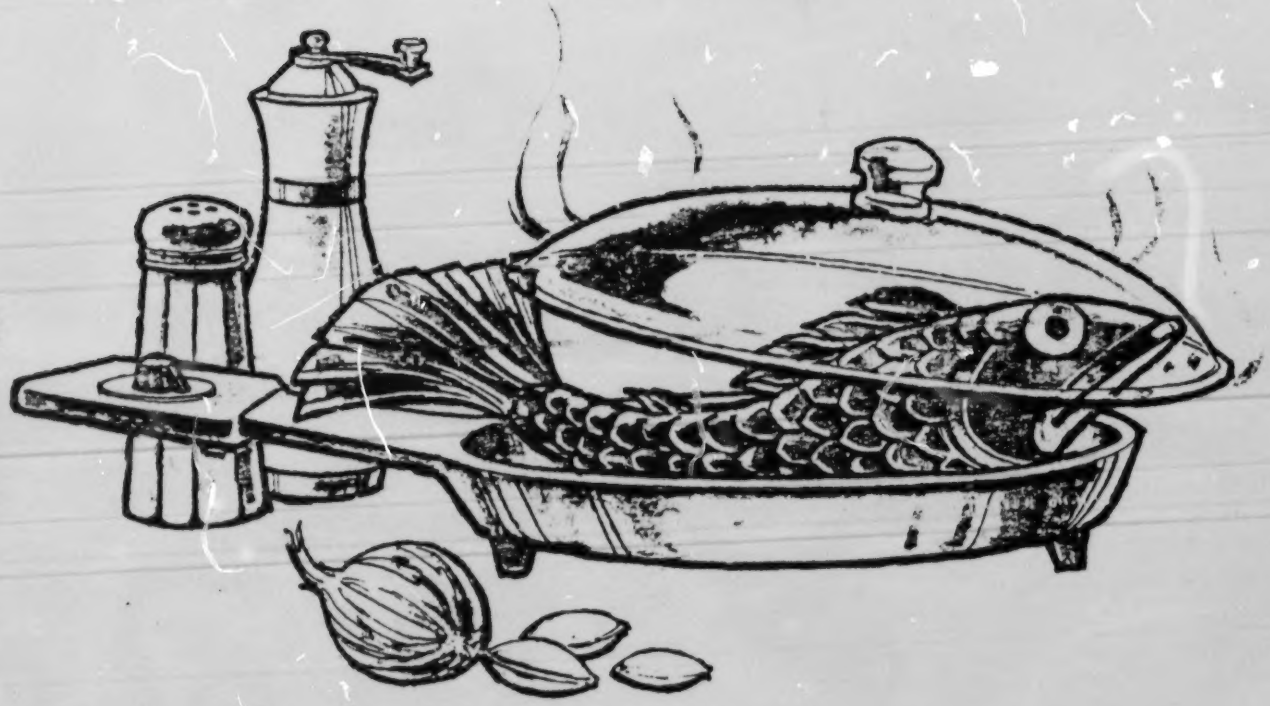
ODORS



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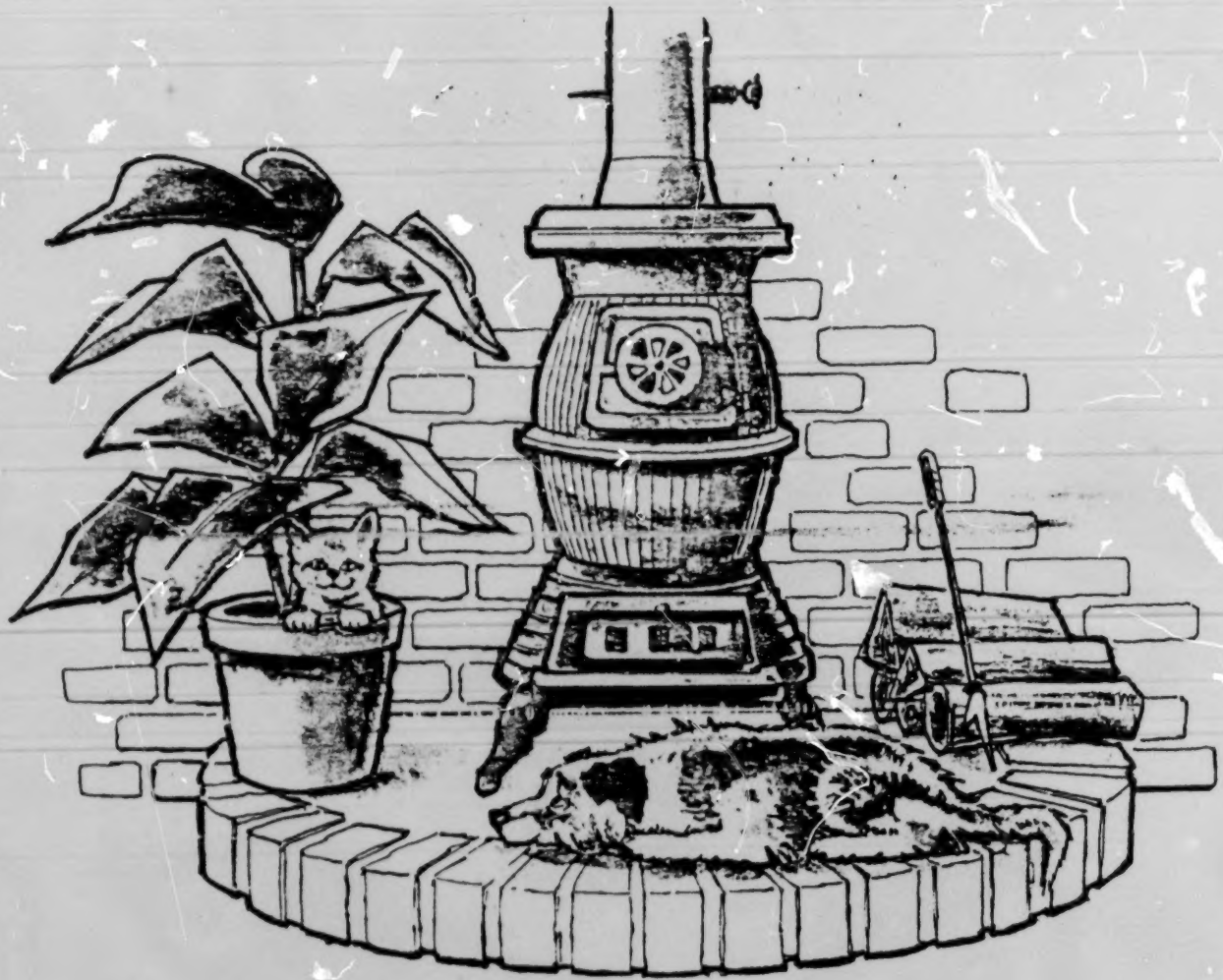

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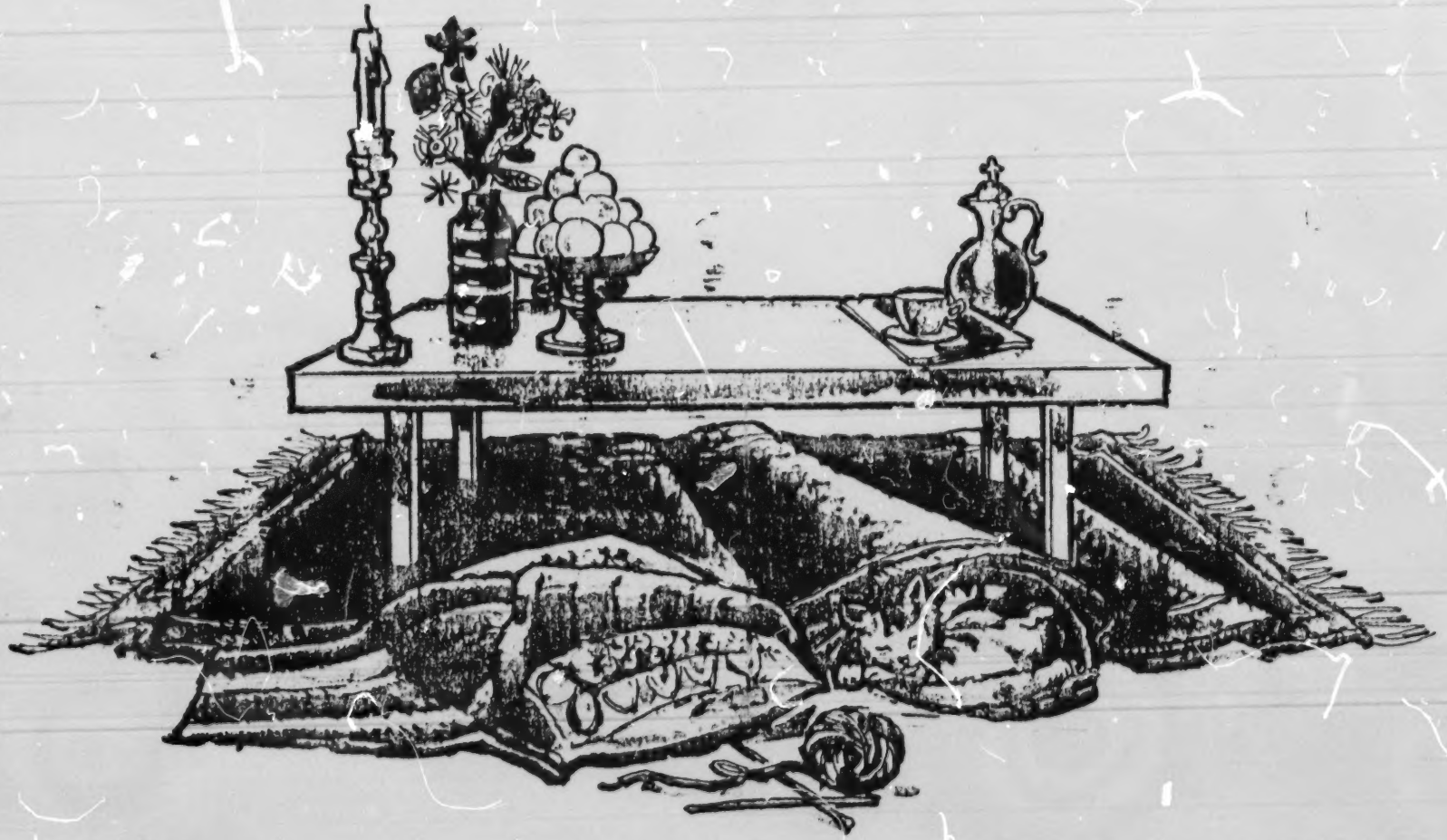

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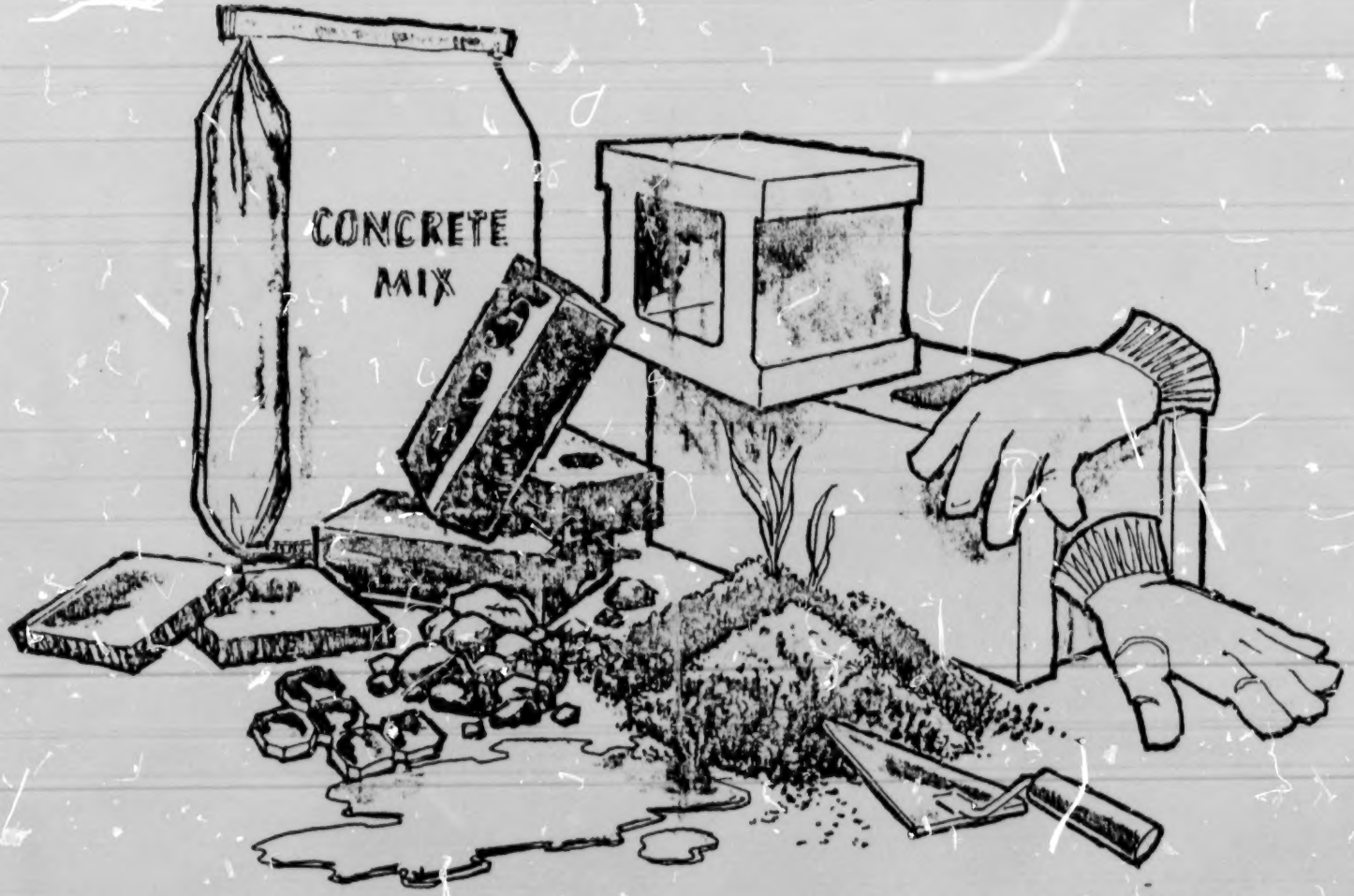
RADON



SUPERINSULATION LTD.

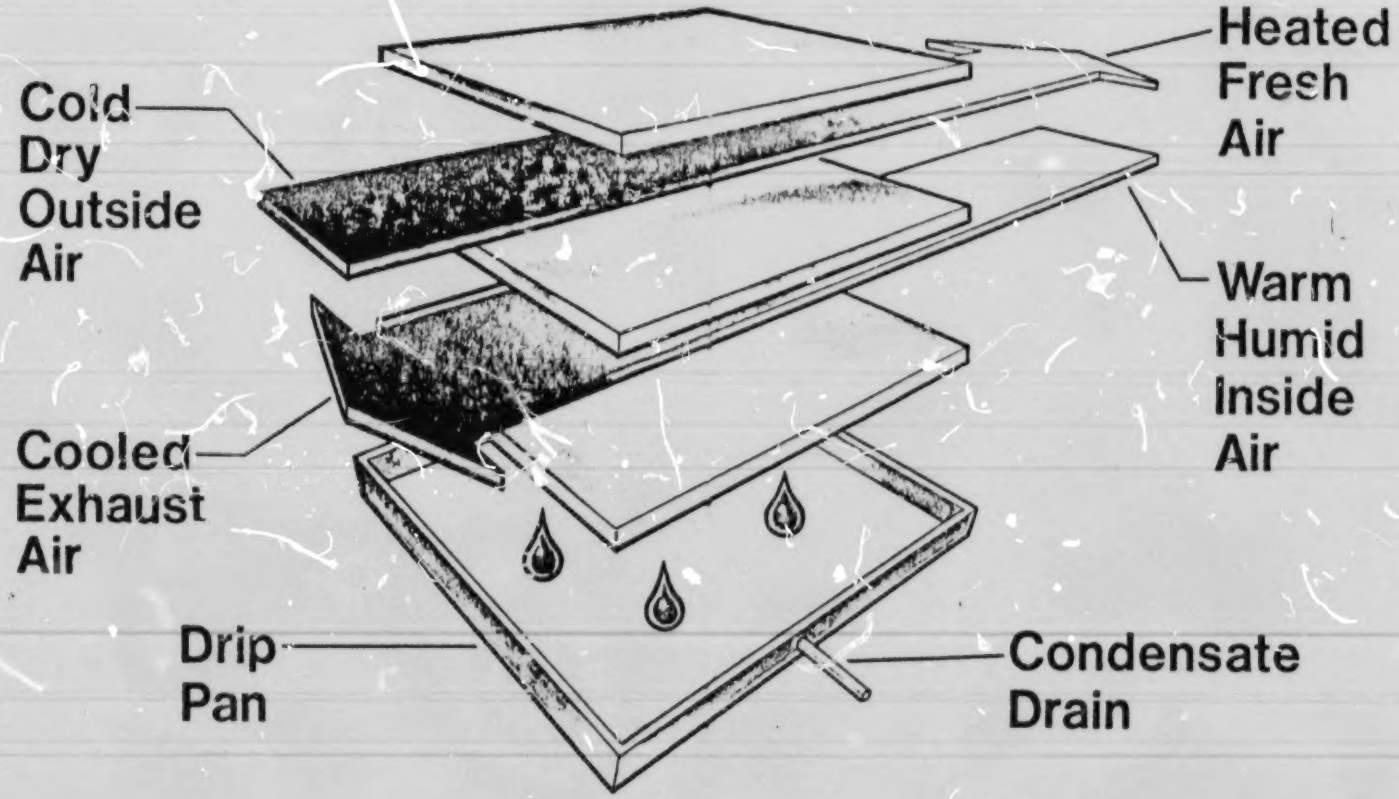
X. AIR-TO-AIR EXCHANGERS

TABLE OF CONTENTS

		PAGE
A.	AIR-TO-AIR HEAT EXCHANGER DESCRIPTION	2
B.	AIR-TO-AIR HEAT EXCHANGER FEATURES	3
C.	AIR-TO-AIR HEAT EXCHANGER INSTALLATION	5
D.	AIR-TO-AIR HEAT EXCHANGER ECONOMICS	6
E.	BIBLIOGRAPHY	9

COUNTER FLOW

AIR-TO-AIR HEAT EXCHANGER



--INTRODUCTION--

Air infiltration rates in superinsulated homes range from 0.05 to 0.25 air changes per hour (ACH), compared with the 0.8 to 1.0 ACH in conventional residential structures. The ACH describes the amount of air equal to the building volume that is replaced by outside air entering the conditioned space each hour. The ACH or rate of infiltration can be greatly dependent upon weather conditions, indoor-outdoor temperature differences, wind speed and direction, etc.

An air management system for a conventional home having relatively large (0.8 to 1.0 ACH) rates of infiltration is not necessary. The natural processes of infiltration and exfiltration can be relied upon for the ventilation needs. However, the tightly sealed vapor barrier and low ACH of the superinsulated home necessitates the use of a controlled mechanical infiltration system -- e.g., an air-to-air exchanger.

Even though superinsulated homes create air circulation with a high level of thermal convection caused by passive solar gain, a mechanical ventilation system is needed. The tight vapor barrier, and well insulated walls and windows do not create the temperature differentials common to conventional homes. The air-to-air heat exchanger, if properly installed and operated, provides the needed house ventilation.

A. AIR-TO-AIR HEAT EXCHANGER DESCRIPTION

An air-to-air heat exchanger incorporated into the air management system of a superinsulated home serves three functions: (1) heat recovery, (2) humidity control, and (3) maintenance of healthy air quality.

(1) Heat Recovery. In winter or summer, the air-to-air heat exchanger brings two air streams of differing temperature together on either side of a heat exchange surface to transfer the heat between them. During winter, on the exhaust side, all the warm, stale, humid air is generally collected and exhausted through one central vent to the heat exchanger. On the supply side, all incoming fresh, cold, outside air enters through another vent to create a balanced flow. The heat exchanger extracts heat from the exhausted air and then transfers this heat to the incoming fresh air with a 60 to 70 percent thermal efficiency. For example, 0°F fresh incoming air can be preheated to 50°F in the air-to-air heat exchanger by the 70°F stale air being exhaused to the outside. At the same time, indoor air is being dehumidified. During summer, an air-to-air heat exchanger can cool and, in some instances, dehumidify the hot outside air. The net effect is improved air quality, compared to the conventional home.

(2) Humidity Control. The second useful function of an air-to-air heat exchanger in the superinsulated home is dehumidification. One consequence of the superinsulated home's air-tight vapor barrier is excess indoor humidity during the winter. The vapor barrier keeps

the cold, dry air out, while keeping the warm, humid air inside. Even though some humidity is very desirable for human comfort and the maintenance of indoor materials, the excess humidity in a superinsulated house may be harmful. The occupants will be uncomfortable, water and frost will form on cold surfaces, like windows, and create an environment where mold can grow rapidly. The air-to-air heat exchanger dehumidifies as the warm, humid air stream being exhausted is cooled and condensed inside the heat exhanger. The excess condensate is drained from the system. The warmed, incoming, fresh, cold, outside air is relatively dry. Thus, air-to-air heat exchanger dehumidifies as it claims heat.

(3) Healthy Air Quality. Maintaining good indoor air quality is the third reason to use an air-to-air heat exchanger. Most potential indoor problems are controlled in the superinsulated home through proper material selection and good vapor barrier application which shield the interior from the outgassing of many pollutants. If the air-to-air heat exchanger is able to control indoor humidity, the other indoor pollution problems are generally handled.

Thus, the air-to-air heat exchanger serves three functions: (1) Heat Recovery; (2) Dehumidification: and (3) Maintenance of healthy air quality.

B. AIR-TO-AIR HEAT EXCHANGER FEATURES

Superinsulation combines air-tight infiltration barriers, heavy insulation and air-to-air heat exchangers. In determining whether or not a home

needs a heat exchanger, a pressure test should be completed to first ensure the house is properly sealed. The pressure test serves as a diagnostic tool to find small leaks and allow patch-ups. Once assured the infiltration rate is low (e.g., .05 ACH), the air-to-air heat exchanger can be effectively used to mechanically provide sufficient amounts of fresh outside air for the home.

Basic screening criteria for air-to-air heat exchangers include:

(1) Cost. The total installed cost should be under $1,000.

(2) Efficiency. The heat recovery ratio should be 70% or better.

(3) Capacity. A variable or dual-speed fan control capability is needed to remove unneeded extra moisture. Typical ventilation requirements should range between 75 to 200 CFM, dependent upon house area and ACH required.[1]

(4) Drain. A plastic pipe with loo and trap is required to drain condensate to the outlet.

(5) Defrost. In cold climates where the outside temperature goes below 0°F, a defrost device is needed to regularly prevent frost from building up on the unit.

(6) Filter. The inlet and outlet streams of the heat exchanger should incorporate removable filters. The filters can be used to clean the air, while also protecting the heat exchange element from clogging.

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[1] The cubic feet per minute (CFM) for ventilation is determined by multiplying the cubic dimension of the living space (i.e., length x width x height) and dividing by sixty. Mechanically ventilate proportional to the CFM necessar to achieve the required ACH.

C. AIR-TO-AIR HEAT EXCHANGER INSTALLATION

In the superinsulated home the installation of the air-to-air heat exchanger is relatively simple. In a house with a conventional forced air furnace system, the heat exchanger can be connected to the cold air return. This approach is frequently used for retrofit applications. The objective is to remove stale air from areas like the kitchen, bath, and utility rooms, while also distributing the warmed, fresh, outside air to the living areas. However, connecting an air-to-air heat exchanger to a conventional furnace and duct system for the superinsulated home is wasteful.

Several efficient applications exist to avoid using the expensive conventional duct systems. Air-to-air heat exchangers are installed several different ways, depending upon house size and the other heating and/or mechanical ventilation systems. For example, in smaller superinsulated homes, window or wall mounted units similiar in appearance to window air conditioners are installed. More frequently, air-to-air heat exchangers are installed with a separate duct system.

Proper installation of a heat exchanger relates to factors like system insulating and ducting, condensate drains, the balancing of air flows and system controls. Most good manufacturers provide complete installation instructions.

Most air-to-air heat exchanger installations are located in the

mechanical room of the main floor or basement. In the basement the air-to-air heat exchanger is hung in the rim joist area, no more than 10 feet from an exterior wall. The air-to-air heat exchanger should be located as close as possible to the exterior wall to minimize the amount of duct runs especially for the fresh air intake. It is desirable to make the return air duct slightly longer than the supply air. This creates a positive pressure, causing the house to exfiltrate, increasing interior comfort.

The outside intake and exhaust vents should be separated by five feet or a corner to avoid cross contamination of the air streams. All duct work should be planned in advance to minimize the length of runs, number of elbows, T's, and connections, to avoid impairing the flow rate and causing a pressure drop.

D. AIR-TO-AIR HEAT EXCHANGER ECONOMICS

Whether the heat exchanger is the logical alternative depends upon its ability to recover heat from the exhaust air stream, control humidity and indoor pollutants. The answer is dependent upon a number of variables including vapor barrier efficiency in reducing ACH and shielding pollutant outgassing, construction material selection and the number of occupants and their personal habits (e.g., smoking, number of baths, cooking, etc.).

The proper indoor ventilation rate is a major issue lacking an answer. Most experts agree the home ventilation rate (ACH) should

be low enough to provide an acceptable and harmless atmosphere. However, this ideal ACH ranges between 0.25 ACH and 1.0 ACH with most agreeing it should be about 0.5 ACH. The economic payback of installing an air-to-air heat exchanger is greatly dependent on the mechanical ventilation rate selected as shown in Table X-1.

If humidity and other indoor pollutants can be controlled with less than ½ ACH, the logical economic decision may be to use direct ventilation in the bath, kitchen and laundry rooms.

Finally, the fan should be sized for continuous operation for a selected air-change rate. The basic operational controls for the heat exchanger should include: (1) a variable or two-speed fan motor; (2) dehumidistat; and (3) some defrost mode to control frost formation on the core surface.

However, the logical economic decision is not always the best decision. Economic value is difficult to measure for some factors--comfort and air quality. Properly sized and operated, the continuous ventilation of an air-to-air heat exchanger guarantees that the comfort and air quality is better in a superinsulated home compared to a conventional home.

TABLE X-1 AIR-TO-AIR HEAT EXCHANGER PAYBACK

IN 2,000 ft^2 MINNESOTA HOME (8500DD)

(ACH) Air Change Per Hour	Required CFM	Heating $ Saved		Payback[1] (if installed cost is:)		
		NG $4.00 ft^2	Elec. 6¢/kWh	$750 NG/Elec	$1000 NG/Elec	$1250 NG/Elec
0.25	67	67	200	11.2/3.7	14.9/50	18.7/6.2
0.50	133	139	398	5.4/1.9	7.2/2.5	9.0/3.1
0.75	200	209	598	3.6/1.3	4.8/1.7	6.0/2.1
1.00	267	279	799	2.7/0.9	3.6/1.3	4.5/1.6

[1] Payback shows the number of years needed to repay the original investment, for example:

$$\text{Payback} = \frac{\text{Heat Exchanger Installed Cost}}{\text{Annual Heating \$'s Saved}} = \frac{\$750}{67} = 11.2 \text{ years}$$

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XI. HEATING AND COOLING SYSTEMS

TABLE OF CONTENTS

	PAGE
A. HEATING AND COOLING SYSTEM SIZING	3
B. HEATING SYSTEM SELECTION	4
C. ELECTRIC HEATING SYSTEMS	4
D. NATURAL GAS HEATING SYSTEMS	5
E. WOOD HEAT	6
F. COOLING SYSTEM SELECTION	7
G. BIBLIOGRAPHY	8

--INTRODUCTION--

Superinsulated homes are like conventional homes and require some backup heating and cooling systems. The difference is in the size of the backup heating or cooling system. A superinsulated home's heating requirements are 80 to 90 percent less than a home built to the Minnesota Energy Building Code. Its cooling requirements are at least 60 percent less. This creates both advantages and problems.

The smaller heating and cooling systems reduce costs and offset part of the cost of the extra insulation and tight constuction. The smaller sizes also create more flexibility in the design of the homes. The problem occurs in selecting a heating/cooling system properly sized for the superinsulated home's small heating and cooling requirements.

Table XI-1 summarizes the calculated heating and cooling requirements for a superinsulated home built in 1981 by Hand Construction in Andover, Minnesota. The energy characteristics are compared to the same basic house built by Hand Construction before 1975. (The Pre-1975 home in Table XI-1 exceeds the current Minnesota building insulation specifications by 20%). A more detailed analysis of the two Hand Construction houses is contained in Section XII - Superinsulation Economics.

TABLE XI-1: HEATING/COOLING COMPARISON

	Pre- 1975 Conventional Specs.	Actual 1981 Superins. Specs	Difference
Auxiliary Heat-in million BTU/Yr	96.3631	15.2554	81.1077 (84.2%)
in Kwh/Yr	28,191	4,470	23,721
Design Heat Loss (000 BTU/Hr at-12°F)[1]	48,970	14,610	34,360 (70.2%)
Auxiliary Cooling in million BTU/Yr	13.0881	5.2796	7.8085 (59.7%)
in kWh/Yr	3,835	1,547	2,288
Design Heat Gain 000 BUT/Hr at 89°F)[2]	24,833	10,018	14,815 (59.7%)

1 Inside temperature set at 65°F

2 Inside temperature set at 75°F

A. HEATING AND COOLING SYSTEM SIZING

With design heat losses (or gains) only 20 to 30 percent of that of homes built to Minnesota Building Code, many rules-of-thumb for the sizing of heating and cooling equipment must be changed. Typical conventional building practices purposely oversized heating and cooling equipment. The result is frequent on-off equipment operation reducing operational efficiency and system life. Oversizing also increases total costs and limits design flexibility.

Fundamental components of superinsulated design includes common sense and paying attention to detail. To properly match the heating and cooling equipment to the superinsulated home's needs requires detailed calculations. Luckily, the American Society of Heating and Refrigeration Engineers (ASHRAE) has developed formulas to accurately predict house heat loss (for winter heating) and heat gain (for summer cooling). The ASHRAE formulas provide a common sense procedure to properly size heating and cooling equipment and provide a slight degree of safety.

The attention to detail will provide more flexibility. Remember, superinsulation means flexibility. Since the heating and cooling system design will be more accurately sized, simpler and thus smaller, the building will be less restricted in planning the location of extensive duct or piping systems. The common sense result is reduce costs in system installation, operation and maintenance costs.

B. HEATING SYSTEM SELECTION

The type of heating and cooling equipment selected for the super-insulated home should be based on three factors:

- Energy Availability (natural gas, oil, electricity, etc.)
- Energy Cost
- Installed Equipment Cost

Although both combustion and electric heating systems have been used in superinsulated homes, electric systems are generally preferred. The available combustion furnaces are simply too large to operate efficiently in superinsulated homes that require 10,000 to 20,000 BTU/hr at design temperature.

C. ELECTRIC HEATING SYSTEM

To avoid the problems related to conventional furnace systems (of oversizing, potential danger from leaky fuels, etc.) most super-insulated homes have installed electric heat. Electric baseboard units, electric radiant ceiling heat, and even small electric furnaces having limited duct work are commonly used.

Currently, electric baseboard and radiant systems are selected most often for superinsulated homes. They are easily sized to match house heating requirements. Because no fuel stack or chimney is needed, envelope penetrations are minimized. Neither requires ducts, radiators, etc. Thus, they save space. These electric systems also require little or no maintenance or service.

Another important attribute of electric heating systems is the flexibility in providing zone control for each room. For example, the bath could be set at 80°F; bedrooms at 55°F; living area at 65°F; and unused rooms below 55°F. Such zone control is very difficult with a duct system. Finally, the installed cost of electric radiant or resistance systems is significantly less than a combustion furnace. For example, 5 kW of baseboard electric heating can be installed for $500 to $700.

The only disadvantage of electric systems is the cost per kWh of electricity. Although in most locations the unit cost of electricity is comparable to oil or LPG, electricity still costs significantly more than natural gas. Yet, the general differential installation cost savings for electric versus natural gas makes the electric systems more cost effective.

D. NATURAL GAS HEATING SYSTEMS

The natural gas industry has recently introduced the condensing or pulse combustion furnace in response to the need for smaller furnaces. Pulse combustion ignites a mixture of natural gas and air in a shoe box sized sealed combustion chamber. It works like an internal combustion engine with a series of 65 to 80 tiny controlled explosions occuring each second inside the sealed chamber. The generated heat is forced downward and heats the water. As the hot gases condense, even more heat is given to the surrounding hot water. The result is a total combustion efficiency approaching a claimed 95 percent. The exhaust gases are

sufficiently cool (between 100°F to 120°F) that no chimney is needed. Exhaust gas is simply vented out the side of the house through a 1 ½ inch diameter PVC plastic pipe.

E. WOOD HEAT

Many superinsulated homes rely on some form of radiant wood heat as the primary or secondary fuel source. Air-tight wood stoves have a seasonal efficiency approaching 65 percent and are the logical choice for superinsulated homes.

It is not recommended to connect wood burning systems to existing oil, gas, or electric furnaces. Wood boilers and/or ducted systems are too large and are not a good match for the superinsulated homes heating requirements.

The air-tight wood stove is becoming increasingly popular in rural areas for heating, where wood is readily available at little or no dollar cost to the occupant. The reduced drafts in the air-tight superinsulated home extend wood burning time, and the air-to-air exchanger provides sufficient ventilation to promote the circulation of warm air to adjacent rooms.

Problems relate to the possibility of increased levels of indoor pollutants and creasote build-up. Indoor pollutants are probably handled safely with proper air-to-air heat exchanger ventilation rates. Creasote build-up in the flue is caused by the tendency of those living in superinsulated homes to build low, slow-burning fires. Thus, ready

chimney access is needed to permit easy cleaning. Both problems are minimized in that it takes only a half to one cord of wood to heat a superinsulated home for a heating season.

F. COOLING SYSTEM SELECTION

Existing central air-conditioning units, like most furnaces, are too large. The cooling requirements for a superinsulated Minnesota home are at least 60 percent less than conventionally heated homes. Combined with a whole house ventilation system, superinsulated homes should be able to maintain a confortable indoor environment through the Minnesota summer. If additional cooling is needed, a small window unit should suffice.

G. BIBLIOGRAPHY

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XII. SUPERINSULATION ECONOMICS

TABLE OF CONTENTS

		PAGE
A.	SIMPLIFIED ECONOMIC ANALYSIS	2
B.	DETAILED ECONOMIC ANALYSIS (LIFE STYLE-COSTING)	10
C.	LIFE-CYCLE COSTING ADVANTAGES	12
D.	PAYBACK	13
E.	RETURN ON INVESTMENT	14
F.	LIFE-CYCLE COST (LCC) METHODOLOGY	
G.	YEARS-TO-POSITIVE CASH FLOW	22
H.	CAN RETIRE LOAN	22
I.	VALUE OF INSTALLED KW CAPACITY NOT NEEDED	24
J.	COST OF ENERGY NOT CONSUMED	24
K.	SUPERINSULATION'S ANNUAL EFFECTIVENESS	26
L.	BIBLIOGRAPHY	30

--INTRODUCTION--

Saving energy, costs money. The first law of economics says "There ain't no free lunch!" The cost to superinsulate is an investment. The investment increases construction costs from $2,000 to $5,000 or 2 to 5 percent. However, these investments create dramatically reduced heating bills.

In 1982, the extra superinsulation features increase annual mortgage costs for new construction $300 to $600, while annual heating bills are reduced by $500 to $1,500. Superinsulation costs the homeowner 30¢ to 40¢ to save $1.00 in fuel bills.

The economic value of superinsulation retrofits varies dependent upon the type and condition of the existing house, and the retrofit strategy selected. Superinsulation retrofits can be a cost effective alternative if the home is undergoing major renovation (e.g., new wiring, plumbing, siding, etc.). In this case, the added incremental cost of the additional superinsulation materials and labor might be cost justified.

A. SIMPLIFIED ECONOMIC ANALYSIS

Insufficient experience exists to provide an economic analysis of superinsulated retrofit. However, numerous examples of successful new superinsulated homes exist.

To illustrate the economic value of new superinsulated homes, HAND HOUSE, in Andover, Minnesota was selected. Hand House is a builder-designed and constructed home. In fact, the same basic house design has been used by the builder since the mid 1970's. This experience allowed the builder to keep exact records of the differential costs required to superinsulate the current superinsulated 1981 version compared to the Hand House specifications prior to 1975. (The pre-1975 Hand House Insulation Specs exceed the current Minnesota building insulation specs -- ASHRAE 90-75-by more than 20%). Table XII-1 compares the insulation specifications and differential costs of the pre-1975 Hand House with the actual 1981 superinsulation version.

The superinsulated Hand House cost $4,894 more to build than the pre-1975 version. The $4,894 includes the 21% mark-up for builder overhead (5%), builder profit (5%), real estate fee (5%) and mortgage points (6%). In total, it costs $5,491.75 more to superinsulate the walls, ceiling, basement slab, etc.

However, because the house is better insulated, it takes much less energy to comfortably heat the house. Thus, the heating system costs

are reduced nearly $600 by eliminating the need for a conventional ducted furnace with 3,500 watts of resistant electric heat and the air-to-air heat exchanger. The added cost to superinsulate was $2.33/ft^2.

TABLE XII-1: SUPERINSULATED HOUSE BUILDING CHARACTERISTICS AND COST

Building Component	Pre-1975 Hand House Specs	Superinsulated Hand House Specs	Added[a] Costs to Superinsulated
Upper Level & foyer walls (R-Value)	15	46	$ 898.12
Stub Walls (R-Value)	15	46	565.37
Rim Joists (R-Value)	5	52	200.26
Ceiling (R-Value)	21	71	1,489.50[b]
Infiltration Controls	1.0 ACH Natural	0.1 ACH Natural 0.4 Mechanical	305.00
Below Grade Walls (R-Value)	15	30	484.00
Basement Slab (R-Value)	1	12	784.00
Air Lock	No	Yes	765.00
Windows	Double Glazed	Triple Glazed-south Quad Glazed non-south	------
Total Building Costs:			$ 5,491.75
Less Reduced Heating System Costs:			(597.69)[c]
Total Added Superinsulation Costs:			$ 4,894.06

Footnotes on next page

TABLE XII - 1: SUPERINSULATED HOUSE BUILDING CHARACTERISTICS AND COSTS (continued)

footnotes to preceeding page

(a) Includes 21% mark-up: overhead (5%); profit (5%); real estate fee (6%); and morgage points (%%).

(b) Ceiling insulation costs include ceiling insulation ($968.00), energy trusses and extra siding ($327.00); wider soffits and sunscreens ($182.00).

(c) Reduced installed cost for Hand House HVAC is the differential installed cost for a regular furnace -- $2,500 -- less the cost of 3,500 watts of baseboard electric ($700.00) and ($1,202.31) for the installed Z-Duct air-to-air heat exchanger.

Z-Duct installed costs include:	$ 500.33	Delivery including freight
	111.82	Duct work Material
	195.00	Labor
	186.16	HVAC Contractor Mark-up
	209.00	General Contractor Mark-up
	$ 1,202.31	

The dollar value of superinsulation can be best illustrated by comparing the building costs two different ways. The pre-1975 house was built to conventional building practices using 2" x 4" studs, 16" on center. The second is the actual Hand House which used the double U.S. wall construction technique. Remember, Hand House is so well insulated, it does not have a conventional furnace. Instead, it has 3,500 watts of radiant electric heat. This system is equivalent to three, 2-slice toasters.

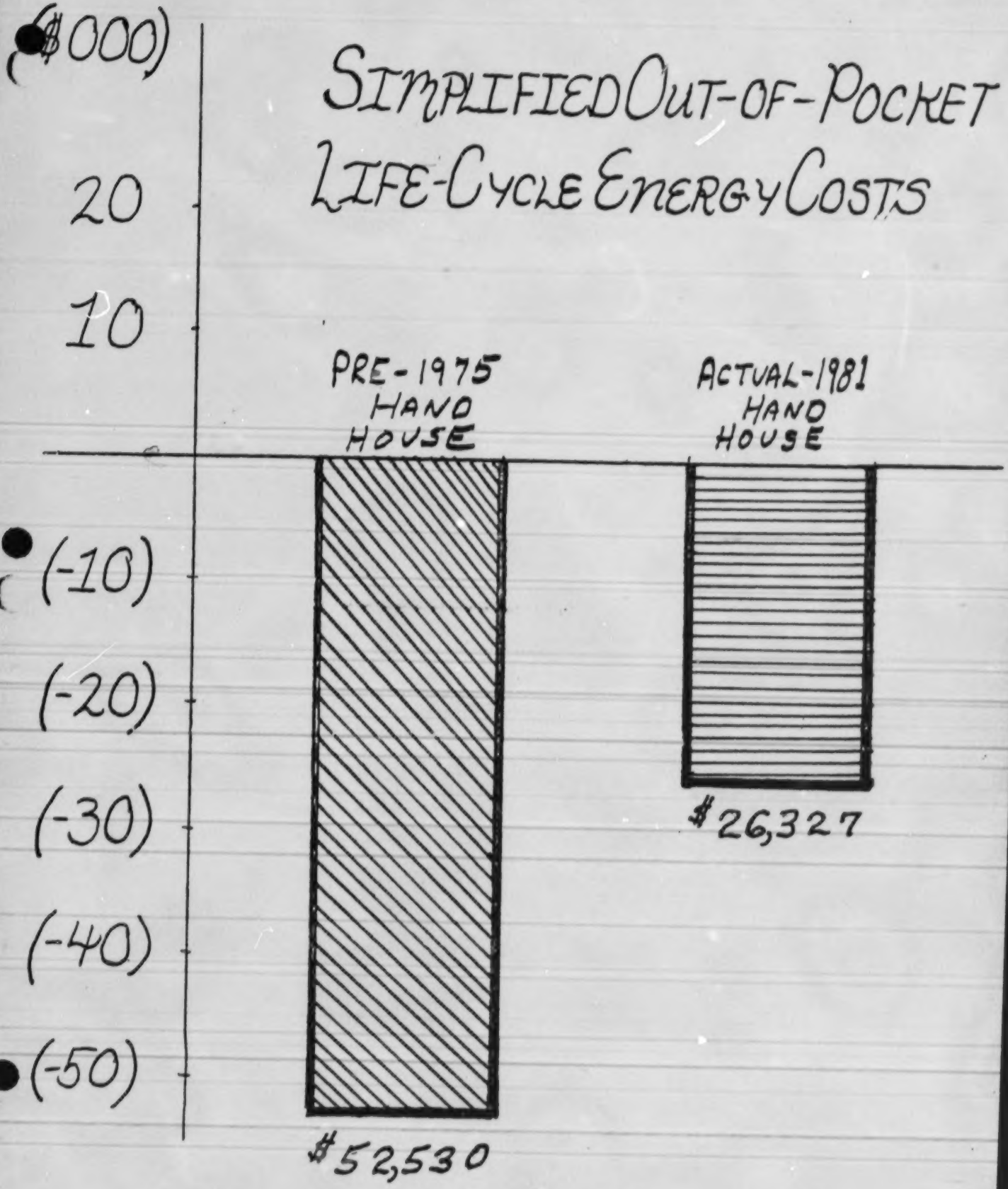
Briefly, when comparing the cost effectiveness of insulating each type of house, the additional morgage costs shown in Table XII-2 for the superinsulation is also energy cost. Table XII-3 traces the total energy costs over the 30 year mortgage for the two houses. The Chart XII-1 graphically shows energy costs for all three alternatives (the first bar shows the energy costs for fuel alone). The major limitation of the simple economic analysis approach over 30 years is its failure to effectively include the impact of several factors, like taxes and inflation. For example, the cost of electricity in this example is assumed to stay at 6.2¢/kWh from 1981 through 2011.

TABLE XII-2: SIMPLIFIED ENERGY LIFE-CYCLE COMPARISON

	STATE STANDARDS (2 x 4 WALL)	SUPERINSULATION STANDARDS (DOUBLE WALL)
1. Investment for superinsulation	-0-	$ 4,984
2. Annual Mortgage Payment @ 12%	-0-	591
3. Tax Credit	-0-	-0-
4. Annual Utility Energy Costs (at 6.2¢/Kwh)	$ 1,751	277
Total Energy Costs	$ 1,751	$ 868

TABLE XII-3: CUMULATIVE OUT-OF-POCKET LIFE-CYCLE COSTS

YEAR	PRE-1975 HAND HOUSE	ACTUAL 1981 HAND HOUSE
0	$ --	$ 591
1	1,751	1,459
2	3,502	2,327
3	5,253	3,195
4	7.004	4,063
5	8,755	4,931
6	10,506	5,799
7	12,557	6,667
8	14,008	7,535
9	15,759	8,403
10	17,510	9,271
↓	↓	↓
30	52,530	26,317



SIMPLIFIED OUT-OF-POCKET LIFE-CYCLE ENERGY COSTS

B. DETAILED ECONOMIC ANALYSIS (LIFE-CYCLE COSTING)

Many bankers, builders and homeowners are already seriously considering superinsulation as one method to deal with current and future energy problems. The proper evaluation of energy investment alternatives in full recognition of their true costs overtime, although not glamorous, is the most effective means to evaluate any financial decision. The consistent implementation of a straightforward investment evaluation method should insure that the decision maker (business person or homeowner) has all the facts and costs associated with each alternative before the final investment decision is made. The Life-Cycle-Cost (LCC) method of investment analysis provides a procedure for estimating the total costs and savings associated with an energy investment over time, taking into consideration changing fuel, maintenance, and operating costs. For this and several other compelling reasons evaluation of investment decisions in terms of LCC has become increasingly more important.

There are several reasons for using LCC. First, more and more financial institutions[1] prefer to see energy related investments (especially retrofits)

---

1 Most external financing for the commercial and industrial sectors is provided by six types of financial institutions: (1) Savings and Loan Associations, (2) Mutual Savings Banks, (3) Commercial Banks, (4) Life Insurance Companies, (5) Mortgage Companies, and (6) Federal Government Agencies.

pictured in terms of LCC[2]. Second, all federal energy agencies strongly promote the adoption of the LCC method. Third, LCC analysis of capital investments reflects a more accurate picture of probable cash flows. In sum, LCC analysis provides businesses and the homeowner a more effective planning tool to anticipate how alternative energy related investments, like superinsulation, influence cash flows and profitability.

Previously, most energy related (as all other) investments were evaluated based upon relatively simple formulas. Although these traditional formulas incorporate the three fundamental investment analysis elements -- the investments, the operating benefits, and the time frames -- they do not accurately incorporate the recent phenomenons of both rapidly escalating energy prices and inflation. Our objective is to illustrate the methodology and advantages of LCC. Commonly accepted assumptions, formats, and procedures are used in examples showing LCC's advantages over the more traditional (simple) investment analysis technicques.[3]

---

2 Also called the Discounted Cash Flow Method, Discounted Rate of Return, etc.

3 All investment analysis methods and their calculations are only underpinning for several broader questions. The time horizon for energy related investments varies from 5, 10, 20 or even more years. Since the future is clouded with much uncertainty, it behooves the analyst to utilize the best engineering--economic guages available. Perhaps, to run each analysis under different assumed conditions if uncertainty appears too great.

C. LIFE STYLE COSTING ADVANTAGES

The LCC method of analyzing energy investments is a relatively new, not widely accepted, concept. The reasons for using the LCC versus the other more traditional methods include:

(1) Most commonly used investment analysis methods are based upon estimated savings during the first year. This provides conservative results when considering the constantly rising costs for labor materials, interest and energy.

(2) The most frequently used investment analysis measure -- payback -- is a rule-of-thumb criterion specifying any investment providing dollar savings equal the the initial investment in five years or less is economically worthwhile. This, as will be shown later, provides conservative results.

(3) The non-LCC methods cannot demonstrate the impact of the energy-related tax credits offered by federal, state, and/or local governments to encourage energy conserving investments.

(4) Energy Costs and savings previously ignored and not included into investment calculations are easily incorporated into the LCC method even if these calculations vary over time.

Numerous other theoretical objections can be leveled at the more traditional (simple) investment analysis techniques. However, it

is probably more instructive to show by example the limitations of the most common methods (payback and return on investment) when compared to the LCC method.

The actual experience for the superinsulated Hand House will serve to illustrate alternative economic analysis techniques using actual Minnesota builder costs (as of July 1981) and insulation values. Both the traditional and detailed Life-Cycle Cost (LCC) analyses are performed to simulate the cost effectiveness of superinsulation to reduce winter heating costs.

D. PAYBACK

Payback is the most common and simple measure of the annual benefits derived from an investment. For the consumer, this equals the added costs to superinsulate beyond the Pre-1975 specs divided by the annual fuel savings.

Superinsulated Investment (see Table XII-1)

$$\text{Payback} = \frac{\text{Average Annual Operating Cash Flow (i.e., Fuel Savings)}}{} = \frac{\$4,894}{1,474} = 3.3 \text{ yrs.}$$

The results show the number of years needed (i.e., 3) to repay the original investment (i.e., $4,898). The payback calculation has obvious drawbacks, i.e., it is relatively insensitive to the investment's useful life (e.g., 30 years), and it does not provide a truly meaningful and comparable criterion of earnings power (profitability).

The speed in which money is repaid is not a convenient way to think about profitability. Without further calculations, all that can be said about the superinsulation example is that viewing only initial investment and fuel savings, the investment pays out in three (3) years with 27 year's extra profit.

The second significant drawback in using the payback method is its inability to handle investments with varying cash flow patterns. Since an average annual operating cash flow is assumed, an investment with rising or declining cash flow patterns (e.g., due to rising energy prices or inflation) will not be properly reflected in the evaluation procedure. The effects of varying cash flow become important when the time value of money is incorporated into the analysis.

E. RETURN ON INVESTMENT

Return on investment is a financial measure expressing the economic desirability of an investment project in terms of a percentage return on the total investment (e.g., $4,894 in Table XII-1). Return on investment is the inverse of the payback formula.

$$\text{Return on Investment} = \frac{\text{Average Annual Operating Cash Flow (i.e., Fuel Savings)}}{\text{Superinsulation Investment}} = \frac{\$1,474}{\$4,894} = 30.1\%$$

However, this method suffers the same limitations of the payback.

F. LIFE-CYCLE-COST (LCC) METHODOLOGY

The inability of traditional investment analysis methods to handle the time value of money or the fact that most energy related dollar

savings and tax effects vary over time severely limits their usefulness.

The LCC method satisfies the key requirement of providing useful, understandable results. While the more traditional methods provided understandable results, their usefulness is subject to question. Table XII-4 shows some of the detailed economic assumptions incorporated into the LCC methodology for the superinsulated Hand House example. Notice, the LCC Format allows a number of component costs to be easily incorporated in the analysis. (This was not possible with the more traditional methods).

Obviously, the LCC analysis becomes extremely sophisticated. Table XII-5 traces the value of superinsulation in reducing 84% of the winter heating bills and homeowener out-of-pocket costs.

It is assumed that the total system cost of $4,894 is financed at an interest rate of 12 percent for 30 years. The initial investment in this case is the required downpayment by the bank, assumed to be 20 percent, which results in a downpayment of $979.

The LCC format incorporates anticipated increased costs for operation and maintenace, sales tax, property taxes, insurance costs, and in a business application, accelerated depreciation expense. Savings (or sources of revenue) resulting from the installation of the superinsulation components include reduced fuel costs, tax savings

TABLE XII-4

RESIDENTIAL
SUMMARY INFORMATION
FOR A SUPERINSULATION
APPLICATION

SOLAR HOMEOWNER: Superinsulated Hand House
SITE: Andover, Minnesota
ANNUAL HEATING LOAD: 96.36 MMBTU/Year
PERCENT OF LOAD PROVIDED BY SUPERINSULATION: 84.20%
SYSTEM COSTS INDEPENDENT OF COLLECTOR AREA: $4894.06

ALTERNATE FUEL TYPE: Electricity
ALTERNATE FUEL TYPE HEATING EFFICIENCY: 100%
PRICE OF FUEL: $18.17/MMBTU Based on .062/KWH

TOTAL INSTALLED COST OF SYSTEM: $4894.06
TERM OF LOAN: 30 Years
INTEREST RATE ON LOAN: 12%
PERCENT DOWNPAYMENT: 20%
AMORITIZED PAYMENTS: $483.27 Based on a monthly payment of $40.27

EARNED INCOME: $25000.00
ITEMIZED DEDUCTIONS W/O SOLAR: $3400.00
NUMBER OF EXEMPTIONS CLAIMED: 4
EFFECTIVE MARGINAL INCOME TAX RATE: 35.55%
FEDERAL MARGINAL TAX RATE: 28.00%
STATE MARGINAL TAX RATE: 14.00%
FIRST YEAR ENERGY SAVINGS: $1473.93
FIRST YEAR TAX SAVINGS: $166.77

FIRST YEAR INFLATION RATES FOR:
(ALL RATES VARY YEARLY)

OPERATING COSTS:	10%
MAINTENANCE COSTS:	10%
INSURANCE COSTS.	10%
ADDITIONAL PROPERTY COSTS:	10%
REVENUE GENERATED:	10%
FUEL SAVINGS:	14%

ECONOMIC ANALYSIS CONDUCTED FOR: 30 Years
DISCOUNT RATE: 12%

and special tax credits or incentives.[4] Now the economic analysis is becoming extremely sophisticated.

Table 5 (Part 1) represents the yearly cash flow calculations and is totaled horizontally along rows, subtracting superinsulation component costs from energy savings to arrive at a yearly net cash flow. Part 2 presents the detailed calculations used to arrive at the "tax savings" column of Part I. For the residential application are zeroed out. In the commerical application, all entries, including the remaining principal and interest paid columns, would be presented.

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4 For the homeowner, the Federal Government provides no tax incentives to save energy in new home construction. However, the State of Minnesota has proposed legislation to provide tax credits for superinsulated homes.

RESIDENTIAL LIFE CYCLE COST ANALYSIS: DETAILED CALCULATIONS
(PART 2)

	REMAINING PRINCIPAL	INTEREST PAID	TAX DEPRECIATION		TAXABLE INCOME		CORPORATE INCOME TAX LIABILITY	
			FEDERAL	STATE	FEDERAL	STATE	FEDERAL	STATE
			(DOLLARS)					
0	3915.							
1	3901.	469.	0.	0.	0.	0.	0.	0.
2	3885.	467.	0.	0.	0.	0.	0.	0.
3	3867.	465.	0.	0.	0.	0.	0.	0.
4	3847.	463.	0.	0.	0.	0.	0.	0.
5	3824.	460.	0.	0.	0.	0.	0.	0.
6	3798.	457.	0.	0.	0.	0.	0.	0.
7	3769.	454.	0.	0.	0.	0.	0.	0.
8	3736.	450.	0.	0.	0.	0.	0.	0.
9	3699.	446.	0.	0.	0.	0.	0.	0.
10	3658.	442.	0.	0.	0.	0.	0.	0.
11	3611.	436.	0.	0.	0.	0.	0.	0.
12	3558.	430.	0.	0.	0.	0.	0.	0.
13	3498.	424.	0.	0.	0.	0.	0.	0.
14	3431.	416.	0.	0.	0.	0.	0.	0.
15	3356.	408.	0.	0.	0.	0.	0.	0.
16	3270.	398.	0.	0.	0.	0.	0.	0.
17	3174.	387.	0.	0.	0.	0.	0.	0.
18	3066.	375.	0.	0.	0.	0.	0.	0.
19	2944.	361.	0.	0.	0.	0.	0.	0.
20	2807.	346.	0.	0.	0.	0.	0.	0.
21	2652.	329.	0.	0.	0.	0.	0.	0.
22	2478.	309.	0.	0.	0.	0.	0.	0.
23	2281.	287.	0.	0.	0.	0.	0.	0.
24	2060.	262.	0.	0.	0.	0.	0.	0.
25	1810.	234.	0.	0.	0.	0.	0.	0.
26	1529.	202.	0.	0.	0.	0.	0.	0.
27	1213.	166.	0.	0.	0.	0.	0.	0.
28	856.	126.	0.	0.	0.	0.	0.	0.
29	453.	81.	0.	0.	0.	0.	0.	0.
30	0.	30.	0.	0.	0.	0.	0.	0.

RESIDENTIAL SUMMARY ANALYSIS
ANDOVER MINNESOTA

1. A RATE WHICH BRINGS THE NPV OF THE CUMULATIVE CASH FLOW TO ZERO IS:
   135.5 PERCENT
2. THE CUMULATIVE NET CASH FLOW EQUALS INITIAL INVESTMENT IN 1 YEARS
3. THE REMAINING PRINCIPAL ON THE LOAN CAN BE RETIRED IN 4 YEARS
4. CUMULATIVE NET CASH FLOW = $ 599565.

ECONOMIC ANALYSIS CONDUCTED FOR : 30 YEARS
... DISCOUNT RATE : 10.00 PERCENT
SALVAGE VALUE OF SYSTEM (PRESENT VALUE) : $ 4894.08

WOULD YOU LIKE TO SEE A YEARLY PRINT OUT
OF THE CASH FLOW ANALYSIS ?
TYPE IN (YES OR NO)

TABLE XII - 5

RESIDENTIAL LIFE CYCLE COST ANALYSIS: CASH FLOW
(PART 1)

	SYSTEM COSTS				SYSTEM SAVINGS/REVENUE		NET CASH FLOW		
YEAR	**** LOAN PAYMENT	OPERATING COST	MAINTAIN COST	INSURANCE COST	PROPERTY TAX	FUEL SAVINGS REVENUE	TAX ** SAVINGS	YEARLY	CUMULATIVE	NPV
					(DOLLARS)					
0	979.(DOWNPAYMENT)							-979.	-979.	-979.
1	483.	0.	0.	0.	0.	1474.	167. *	1157.	179.	55.
2	483.	0.	0.	0.	0.	1680.	166.	1363.	1542.	1141.
3	483.	0.	0.	0.	0.	1916.	165.	1598.	3139.	2278.
4	483.	0.	0.	0.	0.	2184.	165.	1865.	5004.	3464.
5	483.	0.	0.	0.	0.	2489.	164.	2170.	7174.	4695.
6	483.	0.	0.	0.	0.	2838.	163.	2517.	9692.	5970.
7	483.	0.	0.	0.	0.	3235.	161.	2913.	12605.	7288.
8	483.	0.	0.	0.	0.	3680.	160.	3365.	15970.	8647.
9	483.	0.	0.	0.	0.	4205.	159.	3080.	19050.	10046.
10	483.	0.	0.	0.	0.	4793.	157.	4467.	24317.	11485.
11	483.	0.	0.	0.	0.	5464.	155.	5136.	29453.	12961.
12	483.	0.	0.	0.	0.	6229.	153.	5899.	35352.	14475.
13	483.	0.	0.	0.	0.	7101.	151.	6769.	42121.	16026.
14	483.	0.	0.	0.	0.	8095.	148.	7760.	49881.	17614.
15	483.	0.	0.	0.	0.	9229.	145.	8890.	58771.	19239.
16	483.	0.	0.	0.	0.	10521.	142.	10179.	68950.	20899.
17	483.	0.	0.	0.	0.	11994.	138.	11648.	80599.	22596.
18	483.	0.	0.	0.	0.	13673.	133.	13323.	93922.	24328.
19	483.	0.	0.	0.	0.	15587.	128.	15232.	109154.	26097.
20	483.	0.	0.	0.	0.	17769.	123.	17409.	126563.	27901.
21	483.	0.	0.	0.	0.	20257.	117.	19891.	146453.	29742.
22	483.	0.	0.	0.	0.	23093.	110.	22730.	169173.	31620.
23	483.	0.	0.	0.	0.	26326.	102.	25945.	195118.	33534.
24	483.	0.	0.	0.	0.	30012.	93.	29621.	224739.	35486.
25	483.	0.	0.	0.	0.	34213.	83.	33813.	258552.	37475.
26	483.	0.	0.	0.	0.	39003.	72.	38592.	297144.	39502.
27	483.	0.	0.	0.	0.	44464.	59.	44039.	341184.	41567.
28	483.	0.	0.	0.	0.	50688.	45.	50250.	391434.	43671.
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THE $ 0. TAX CREDIT IS INCLUDED IN THE FIRST YR'S TAX SAVINGS
** TAX SAVINGS ARE CALCULATED BY MULTIPLYING THE PROPERTY TAX AND INTEREST PAID BY THE HOMEOWNER'S EFFECTIVE MARGINAL INCOME TAX RATE

Following Part 2, is a set of summary financial performance indicators. The first is the internal rate of return (IRR) on the superinsulation investment. The solution is 135.5 percent. Formally defined, the internal rate of return [5] is the rate which forces the net present value (NPV)[6] of a series of cash flows to equal zero. The rate of return is equivalent to the interest rate an individual receives when purchasing a bond. Thus, a better indicator than the traditional Return on Investment.

---

5 The rate of return is determined by finding the value of K such that:

$$0 = \sum_{t=0}^{n} = \frac{R_t}{(1+K)}$$

where: t = Time in years
n = Use system life in years
R_o = Downpayment
R_t = Yearly cash flow
K = Discount rate/100

6 NPV, is the present value of the expected net cash flow of an investment, discounted at the cost of capital, less the initial cost outlay of the project.

$$NVP = \sum_{t=1}^{n} \frac{R_t}{(1+K)} - C$$

C = Investment cost (i.e., $4,894)
R_t = Net Cash Flow
n = Investment's expected life (i.e., 30 years)

Table XII-6 summarizes several other LCC indicators that view the investment from the consumer's and utilities point of view.

G. YEARS-TO-POSITIVE CASH FLOW

The next more sophistiated financial performance measure is "Years-to-Positive Cash Flow", or, where the consumer is no longer cash-out-of-pocket. This occurs in the first year for the superinsulated Hand House. That is, the annual cost of heating in the Pre-1975 house ($1,722) is greater than the added mortgage and heating costs in the superinsulated Hand House ($591 + $176= $767).

H. CAN RETIRE LOAN

The consumer also wants to know what point during the 30 year mortgage (principle and interest) can the additional costs (principle and interest) for superinsulation be retired. In Andover, Minnesota, this occurs in the fourth year. From this point on, all system savings are clear and free of any system costs except for operation, maintenance, insurance, and property taxes.

Table XII-6: LIFE-CYCLE COST ANALYSIS: SUPERINSULATED HAND HOUSE

	Pre-1975 Specs	Superinsulated Specs
Consumer Perspective		
Auxiliary Heat (in million BTU/yr.)	96.3361	15.2554
Thermal Integrity Factor (BTU/SF/DD)	5.71	.90
Design Heat Loss (000 BTU/hr. @ Design Temp.)	48.970	14.610
Consumer Electric Cost		
Consumer Electric Cost	6.29¢/kwh	6.2¢/kwh
Added Costs		$ 4,894.06
Simple Payback		3.3
Years-To-Positive Cash Flow		1-
Can Retire Loan		4-

I. VALUE OF INSTALLED KW CAPACITY NOT NEEDED

The second half of Table XII-7 assesses the value of superinsulation for the electric utility given certain assumptions. (The utility is winter peaking and is near capacity with little reserve margin.) The analysis suggests the utility could reduce the need to provide 11.6 kW of installed killowatt (kW) capacity by encouraging builders to use superinsulated versus Pre-1975 specs for building homes. The bottom line for the site value of installed kW capacity not needed would be $423. This compares quite favorably with the cost of $1,000 + per installed kW required to build new generating capacity. The super-insulated home has a longer time constant which also provides the utility more flexibility for alternative load management strategies.

J. COST OF ENERGY NOT CONSUMED

Utilities and consumers can both view these energy savings from another perspective -- the cost of energy not consumed. This is the 30 year principle and interest less tax savings the consumer pays for the energy saving investments in order to reduce energy (i.e., electricity, oil, etc.) consumption. For example, in 1981 the superinsulated Hand House owner pays 1.6¢/kW not to consume 6.2¢/kW electricity from the utility in Andover, Minnesota. If the analysis depicted the cost of energy saved in oil, the owner of the superinsulated Hand House would be paying the energy equivalent of 42¢/gal. fuel oil for the added costs to superinsulate over the 30 year house mortgage.

TABLE XII-7: LIFE-CYCLE COST ANALYSIS: SUPERINSULATED HAND HOUSE

	Pre-1975 Specs	Superinsulated Specs
Electric Utility Perspective		
Installed kw required at Designed Temperature	14.3	4.3
Installed kw with 15% Reserve Margin	16.5	4.9
Site Cost of Constructed Installed kw not needed at Design Temperature		$ 422.90
Annual kwh Consumption for Heating	28,191	4,470.00
Cost of kwh not Consumed [1]		1.64
Cost of Fuel Oil not Consumed [2]		42¢

(1) Derived by dividing added costs by amount of installed kw not needed.

(2) Derived by dividing 30 year principal and interest less tax savings by kwh's saved or fuel oil assuming 65% furnace efficiency.

LCC analysis (including the summary financial indicators) provides a more realistic insight over the traditional investment measures. This is due to the fact that LCC analysis evaluates many more factors including: (1) all investment costs (2) operation and maintenance costs (or savings), (3) insurance costs, (4) interest expense, (5) alternative depreciation methods for business applications, (6) federal and state income taxes, (7) property taxes, and (8) tax credits and incentives. The eventual result provides a clearer picture of the total costs and savings for energy related investments.

K. SUPERINSULATION'S ANNUAL EFFECTIVENESS

Numerous technical reports and journal articles during the past several years have described how superinsulation could dramatically reduce winter heating bills by 80 or 90%. However, few have actually addressed the problem of what impact superinsulation may have on reducing summer air-conditioning costs. Although much speculation and some previous calculation suggests that superinsulated homes are sealed from the heat as well as the cold.

At present, several superinsulated homes are near or already in construction in warm U.S. climates. However, to date, no performance monitoring data exists to confirm that superinsulated homes are really like thermos bottles. It is an established fact that superinsulated homes retain warmth with little heating. But can superinsulated homes retain cool with little cooling?

Table XII -8 summarizes the effectiveness of superinsulation to reduce summer cooling requirements. The most recent ASHRAE calculation procedure ASHRAE FUNDAMENTALS (1981) was used to predict that the design heat gain would be reduced by 60% for the superinsulated Hand House.

Table XII-9 summarizes the cost effectiveness of superinsulation to reduce winter heating and summer cooling costs. Predicted annual fuel bills for the superinsulated Hand House are reduced by $1,613. The result is a payback of 3.0 years.

TABLE XII-8: SUPERINSULATION'S EFFECTIVENESS TO REDUCE COOLING REQUIREMENTS (SUPERINSULATED HAND HOUSE)

	Pre-1975 Insulation Specs	Actual 1981 Superinsulation Specs
Degree Days Cooling	527	527
Design Heat Gain (BTU/Hr)	24,833	10,018
Annual KWh Consumption for cooling	3,835	1,547
Consumer Electric Costs	6.2¢/kWh	6.2¢/kWh
Savings Attributable to Superinsulation:		$ 142/Year

TABLE XII-9: SUPERINSULATION'S ANNUAL EFFECTIVENESS

(SUPERINSULATED HAND HOUSE)

House Location.....Andover, Minnesota

Energy Saver (kWh)

Winter	23,721 ($1,471 @ 6.2¢/kWh)
Summer	2,288 ($142 @ 6.2¢/kWh)
Annual	26,009 ($1,613 @ 6.2¢/kWh)

Economic Summary

Investment	$ 4,894
Fuel Savings	1,613
Simple Payback	3.0 Years

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XIII. MARKETING SUPERINSULATION

TABLE OF CONTENTS

	PAGE
A. MARKETING PHILOSOPHY	3
B. SUPERINSULATION BENEFITS	5
C. BIBLIOGRAPHY	8

--INTRODUCTION--

Superinsulation is the builders' solution to the residential energy problem. Superinsulation consists of simple modifications of existing building techniques using materials already at the lumber yard. Compared to other solar houses which use active collectors, extra glass or mass to maximize sunshine, super-insulated homes seek to minimize fuel bills. Instead of relying on high technology and sophisticated architectural design, superinsulated homes rely on the builder paying attention to detail and using common sense.

The conventional appearance of the superinsulated home is probably its strongest selling point. The only visible differences are the foot deep windows and the lack of a central furnace system. The extra deep window frames and sills are an attractive feature. They are frequently used as window seats, mini-greenhouses for potted plants, or for placing decorations. The use of electric base-board or radiant electric systems in the superinsulated house eliminates the bulky furnace and duct systems common to conventional homes.

The other major noticeable difference is that superinsulated homes are quieter than conventional or most other types of solar homes. The extra insulation eliminates most outside noise. The lack of a

conventional furnace system or the fancy pumps and other gadgets associated with many other solar systems also reduces the inside noise level.

The marketing and dollar value of these differences is now being recognized by realtors and appraisers. Consumers are increasingly aware and demand more energy efficiency as fuel costs continue to rise. Superinsulated homes are seen as representing value by those who want energy efficiency, but do not want to pay for the fancy solar features. Superinsulation in Minnesota is four times more cost effective than a passive trombe wall and twenty-five times more cost effective than active collectors to heat a home.

Unlike other solar or energy efficient homes, few market barriers exist. Consumer knowledge and demand is growing for superinsulation construction. The superinsulated home is a special solar home that seeks not to maximize sunshine, but minimize house buyer mortgage and energy costs.

A. MARKETING PHILOSOPHY

All members of the housing industry must also be salespeople. Selling the superinsulated home is not much different than selling a conventional home. Skillful realtors and builders should stress several points in developing a successful market or promotional plan.

(1) Superinsulation can not overcome a poor location, overpricing or an aesthetically obnoxious design. The house needs to be compatible in price and design with existing neighborhoods.

(2) Superinsulation is not the only thing the potential house buyer looks for. Buyers are still interested in location, price, design and resale value. The superinsulated features should be identified and publicized strongly. Take time to explain these features to potential buyers. Those superinsulated features that enhance these traditional concepts should be identified.

(3) The growing reputation of superinsulation is selling the concept. If the potential buyer is sold on superinsulation--the builder or realtor should be ready to re-enforce the buyer's committment to superinsulation.

(4) Builders and realtors should make every effort to convince lending agencies the extra superinsulation costs are a good investment and should be included in the mortgage.

(5) Sellers need to develop attractive and informative brochures explaining superinsulation. This also requires the salespeople be trained and knowledgeable.

(6) Sellers should be able to demonstrate the economic value of superinsulation to the potential buyer. Stress superinsulation as an investment that quickly pays for itself. Good graphic representations of costs and savings help get these points across to the potential consumer.

(7) Conduct open houses. Allow people to walk through and see the home in operation in the winter without the furnace turned on. This is the most effective demonstration that superinsulation works.

B. SUPERINSULATION'S BENEFITS

Owners of superinsulated houses are not the only beneficiaries of superinsulation. Almost all other sectors of society, except for maybe fuel distributors, benefit from the construction of more superinsulated structures. Remember:

SAVE ENERGY.....

SAVE DOLLARS.....

CREATE PROFITS!

This is true for the buyer, the builder, the realtor, the banker, the utility, the government, and thus, society.

-Housebuyers like "superinsulation" because it lowers "out-of-pocket" costs -- SAVE DOLLARS.

-House builders and realtors like "superinsulation" because these houses have higher resale values, sell quick, and CREATE more PROFITS. (The higher sales value increases the total dollars earned on fixed percentage fees for real estate commission; builders overhead, fees and profit.)

- Bankers like "superinsulation" because buyers and builders borrow more money which CREATES more PROFITS. (Note: $4,000 bank 30-year mortgages @ 12% yield $14,900 at maturity.)

- Utilities like "superinsulation". Why? A superinsulated house needs a small 5 killowatt (kW) (17,000 Btu) furnace. A conventional house needs at least a 20 kW (68,000 Btu) furnace, a difference of 15 kW. Since new electric power plants cost $1,000 per installed kW, the utility company saves $15,000/house for new installed capacity. Utilities like SAVING DOLLARS and making PROFITS.

- Government likes "superinsulation" because it creates new jobs (1 to 4 extra labor days per house), saves energy, reduces the need for imported oil, reduces unemployment and national debt. Thus, creating more Gross National Product (GNP).

- Finally, home buyers like "superinsulation" for more than saving dollars. Superinsulation's extra cost may be justified since a more healthy and more comfortable indoor living environment is created. The air-to-air heat exchanger, proper materials selection, and air-tight vapor barrier improves air quality compared to a conventional home. More comfort is created because body heat loss is greater to a cold wall, than a warm wall. In the superinsulated home interior and exterior (R-30+) walls are warm. Thus, the uniformly warm walls of the superinsulated house create a more comfortable environment allowing the thermostat to be turned down to

maintain the same comfort level. (Although it is difficult to place a dollar value on improved comfort and health, few say indoor plumbing is not cost effective.)

Superinsulation should be considered by those considering to build or buy a new house. House building techniques should emphasize reducing total house costs including mortgage and fuel bills. Superinsulation is the house building energy alternative that provides the best return on investment.

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XIV. CONSUMERISM

TABLE OF CONTENTS

		PAGE
A.	CONSUMER QUESTIONS AND ANSWERS	2
B.	BIBLIOGRAPHY	9

--INTRODUCTION--

Many Minnesota homeowners are concerned about the growing cost of keeping warm in winter and cool in the summer. In spite of government utility efforts to hold costs to a minimum, higher prices for fuels and general inflationary pressures continue to increase. Rising energy costs are expected to be a continuing trend that will create a serious problem for many homeowners.

Consumers are increasingly interested in doing something that will reduce future energy costs. Recent consumer surveys have identified energy efficiency to be the most important factor in the decision to purchase a new home.

The superinsulated home is a viable option for those wanting to control future energy bills. Providing direct answers to the many questions consumers have about superinsulation is an effective way for consumer education.

Question: Does the superinsulated home save on energy bills?

Answer: Yes.

Question: How much savings can the homeowner expect, compared to a house built to the Minnesota building code?

Answer: Superinsulation will reduce heating costs by 80% or more, and air conditioning costs about 60%.

Question: How much do these savings mean to me?

Answer: These savings were based on typical energy usage by a typical household. Since few of us are typical, it is very difficult to discuss energy savings without knowing more about the family involved. Experience shows that different families use energy in different ways. However, if the homeowner uses a combination of superinsulation and common sense, the energy savings are easily achieved.

Question: How expensive are the extra features of the superinsulated home?

Answer: The added cost generally ranges between $2,000 and $5,000 for new construction. The cost varies basically on the size of the home.

Question: Why should the homeowner pay more for the superinsulated home?

Answer: Because the homebuyer cannot afford not to. While the initial cost of the superinsulated home may be $2,000 to $5,000 more, the energy savings will pay for the extra cost in about three (3) years. The consumer pays 30 to 40 cents in increased mortgage payments to save a $1.00 in fuel bills.

Question: Energy costs have increased a lot in the past 10 years. Will they continue to increase in the future?

Answer: Yes! All energy costs will continue to increase as almost everything else has, but faster! Home heating with natural gas will become nearly as expensive as fuel oil, LPG and electricity, after natural gas prices are decontrolled by 1985.

Question: Are utilities in favor of superinsulated homes?

Answer: Yes! Several utilities and utility organizations, such as the North Central Electric League, have supported superinsulation construction, demonstration, and education efforts. For example, Northern States Power (NSP) funded the construction of the superinsulated NorthStar House, in Brooklyn Park, MN. The house is regularly available for public inspection. NSP is now planning the construction of several new superinsulation demonstration homes.

Question: Why would the utility want to help the homeowner reduce heating bills? Doesn't that reduce utility income?

Answer: Yes and no. Utilities view superinsulation much as consumers, a way to reduce energy costs. Since the first energy crisis, caused by the Arab oil embargo, the price of electricity has doubled or tripled. The utilities' cost for coal to create electricity has increased by 500%. Inflation has caused dramatic increases in other areas. This is especially true in the area of new electric power plants, which has skyrocketed.

The utility, by law, must build enough power plants to meet customers' instant demands for electricity on the five or six hottest or coldest days of the year, those days when everyone runs their air conditioners or furnaces. But during the rest of the year, those extra power plants are idle, un-needed. Nevertheless, the mortgage payments paid for the utility power plant capacity, that is needed for only a few days a year, is large. How large? What is the mortgage on a building costing $500-$1000 million?

The utility does not want to build new expensive power plants which reduce their profits and increase customer rates. If the majority of North Central homes were superinsulated homes, the peak periods of demand for power....the hottest and coldest days....would be dramatically reduced. It is two or three times more cost effective to save energy than to build new power plants to create it.

So, if the utility customers build superinsulated homes, it would allow the utility to use existing facilities more efficiently and pass those savings on to utility customers.

Question: How comfortable is the superinsulated home?

Answer: The superinsulated home has no cold or hot spots on the walls, floor or ceiling to cause discomfort. This means these homes provide a much more comfortable living environment.

Question: Some say you can heat a superinsulated home with four (4) toasters. Is this true?

Answer: Yes and no. Many superinsulated homes have auxiliary heating systems which require the same amount of electrical energy needed to operate four toasters; about 5 kilowatts.

Question: What happens if the home doesn't have all the superinsulated features described in the curriculum?

Answer: It still might qualify as a superinsulated home. Remember, the superinsulation recommendations are not requirements. Also remember, superinsulation means flexibility. Sometimes the house and windows cannot be oriented to maximize solar gain. Sometimes you many want a large window to the north to take advantage of a view. If common sense is used, not perfectly following superinsulation guidelines, it will only slightly effect energy efficiency.

Question: What about the use of solar collectors for home heating?

Answer: Superinsulation is the most economical choice.

Question: What do builders think of superinsulated homes?

Answer: Builders are interested in selling homes. A recent study by the National Association of Home Builders discovered 80% of consumers surveyed felt low fuel bills to be their number one concern. Builders want to build homes that the homebuyer wants.

Question: What do realtors and appraisers think about superinsulation?

Answer: They are identifying energy efficiency as a factor in determining a home's market value. They find superinsulated homes

easier to sell to prospective buyers. Realtors also find that financing is easier to obtain for energy efficient homes. Thus even bankers are taking interest in promoting energy efficiency.

Question: I've read articles by famous solar experts in magazines like New Shelter identify a number of reasons why superinsulation was not a "balanced solution". Is superinsulation the "balanced solution"?

Answer: We don't know if superinsulation is the most "balanced solution", it is only the most cost effective.

Question: Some "experts" say the superinsulated home has very limited window area where "one has to go outside to see the sky, clouds, birds, weather and trees bending in the wind". Is this true?

Answer: No! A good superinsulated rule-of-thumb specifies a ratio of 12 percent glass area to floor area (8 percent south-facing, 4 percent facing other directions). This is consistent with most state and federal (e.g., VA and FHA) building requirements.

Question: Are there health problems with poor indoor air quality in the air-tight superinsulated home?

Answer: There are fewer air quality problems in superinsulated homes than in conventional or many active or passive solar homes. In superinsulated homes, careful material selection and the air-to-air heat exchanger avoid problems caused by building materials, like formaldehyde.

Question: Are there health problems caused by carbon monoxide and oxides of nitrogen and sulfer?

Answer: Not usually. Oxide caused health problems are almost always linked to unvented gas cooking. Close inspection of books about superinsulated homes reveal they almost always use electricity

for cooking and heating. If a combustion furnace is used, it is closed looped. Combustion furnaces and appliances are seldom used in superinsulated homes because most early available current gas or oil furnaces are too large to operate efficiently in the very energy efficient, superinsulated home.

An oxide problem worth mentioning, is the potential for photochemical oxidation where increased glass area for many passive solar homes provides additional sunlight, further promoting the photochemical oxidation and conversions of indoor air pollutants (e.g., sulfar oxides from gas cooking) to other health risk products (e.g., sulfuric acid mists).

Question: What is "radio-active radon gas" and is it a problem?

Answer: Radon is a naturally occuring radioactive gas found in soils, ground water, concrete, bricks, tile and many other building materials. It poses no problem for most homes, except if there is increased use of radon producing materials for thermal mass, significant radon outgassing from the soils into the home, and generally poor household ventilation.

Question: Does this mean the tightly sealed superinsulated home could have a radon problem?

Answer: Possibly, but not likely. The superinsulated home does not need nor typically use radon producing materials, like masonry (trombe) walls, floors, etc. The continuous vapor barrier in the superinsulated home shields the inside from the outgassing of radon from soils or ground water (the prime sources of radon). Radon problems attributable to poor ventilation are also

avoided with the use of an air-to-air heat exchanger which is standard equipment for superinsulated homes.

Question: Is it true that "the challenge to architects is destroyed (in a superinsulated structure)? Instead of happily finding ingenious ways to put solar energy to work....architects can plod ahead with the dull, out-moded designs of yesterday, merely bolstering them up with superinsulation?"

Answer: No! Superinsulated structures are as design-flexible as solar ones. Existing superinsulated homes range from reproductions of colonial New England saltboxes; to rachers; to contemporary split-entries; to even a 40 foot diameter sphere with R-50 walls, near completion in Northfield, MN.

Question: Is it better to use passive solar design pricipals designing to maximize a home's Solar Savings Fraction (SSF)?

Answer: Possibly, but it is more cost effective to design a home not to maximize sunshine, but rather to minimize out-of-pocket homeowner heating and mortgage payments.

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APPENDIX A

MARKETING ASSISTANCE PACKAGE

The continued use of the superinsulation curriculum materials is the primary objective. Attached are a number of ideas for public service announcements or news releases for TV, radio, and newspapers to promote continued superinsulatin education efforts. These materials are only part of a comprehensive effort developed by Jeanne Brownback, of the Rochester AVTI. Those seeking the complete document should inspect page i.

Credits

this handbook was developed by the:

CONSUMER ENERGY EDUCATION CURRICULUM PROJECT
Adult Vocational Education Division
Rochester Area Vocational-Technical Institute
1926 Southeast Second Street
Rochester, Minnesota 55901

Dr. Harry N. Vakos
Superintendent of Schools

Dr. Charles E. Harwood
Director, Rochester AVTI

William E. Weiser
Coordinator of Adult Vocational Education

Jeanne Brownback
Leader, Consumer Energy Education Project

promotional concepts and design by:

ADS & ART
Bruce and Sara Qualey
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INTRODUCTION

Consider the work that goes into putting on a series of courses like those in the consumer energy program. It's worth the effort only if enough people attend. And this is not something you should leave to chance.

The success of the program depends largely on your ability to communicate with the public. You must: 1) Make people aware of what you're doing; 2) Stimulate interest and participation. This is the job of advertising and publicity.

Paid advertising and free publicity go hand in hand in promoting a program like consumer energy education. However, because your publicity efforts depend upon the good graces of others, you lack control and you seldom get enough of it. Advertising is a paid communication--this gives you control over what you say and when and where it is said.

To help you successfully promote consumer energy education, a complete advertising program has been developed for your use. All of the components of this program feature the same theme and creative approach. This consistency will enable you to maximize your advertising effectiveness. Refer to this manual as a guide to help you use the various advertising materials.

NEWSPAPER

Materials: 3 column x 10" ad--two slicks

2 column x 5" ad--two slicks

Module illustrations--two each of 14

How to Use

3 column x 10" Ad. This is designed to promote the entire energy education program or to promote several courses at the same time. It may be enlarged or reduced in size as needed. Just have your newspaper add the copy you desire in the indicated space (courses, dates, times, fees, etc.) and have them add your school identification and phone number at the bottom. SEE EXAMPLE A, EXAMPLE B.

2 column x 5" Ad. This ad is designed specifically to promote a single course. It may also be enlarged or reduced in size as needed. Select the desired module illustration from the 14 illustrations in your kit. Your newspaper can insert it into position as indicated. SEE EXAMPLE C. There is room for them to add appropriate course title, date, time and place, as well as your school identification and phone number.

Module Illustrations. There is an illustration for each course module. They are to be inserted in the small newspaper ad as indicated. They are also to be used in the statement stuffers.

Where to Run

Most newspapers enjoy fairly even readership throughout, but you may wish to request a position as far forward in the paper as possible.

RADIO

Materials: 60-Second Cut--31 seconds for local announcer
30-Second Cut--8 seconds for local announcer
30-Second Cut--20 seconds for local announcer

How to Use

60-Second Cut. This spot is designed to sell the entire program as well as two specific courses. Refer to the 60-second radio script in this manual--EXAMPLE D. You'll notice a number of blank spaces in the local announcer's copy. Just fill them in to fit your situation. Then type out this copy and bring it along with the tape to your local radio station. (It might be a good idea to have an extra dub made for you just for safe keeping).

30-Second Cut--8 seconds for local announcer. This serves as both a radio spot and as audio for the TV commercial. It sells the energy education program in a general way--SEE EXAMPLE E. At the end of the spot, there are 8 seconds for your "tag". Just fill in the blanks on the script, type out and give to your local announcer to read.

30-Second Cut--20 seconds for local announcer. This spot is designed to give you time to sell one specific course after a 10 second "lead-in". Refer to script--EXAMPLE F--and fill in the blanks in the copy as desired. Type out and give to your local announcer.

NOTE ON RADIO COPY FOR LOCAL ANNOUNCER: This is merely suggested copy--you can, of course, say anything you wish during that time.

When to Run

Radio is generally at its peak in the morning between the hours of 6:00 AM and 10:00 AM. If you buy spots during this time period, you may have to pay a little more, but the higher audience level justifies the increased expense. A second prime time is from 3:00 PM until 7:00 PM. This is called "Afternoon Drive" and it's when people are driving home from work.

TELEVISION

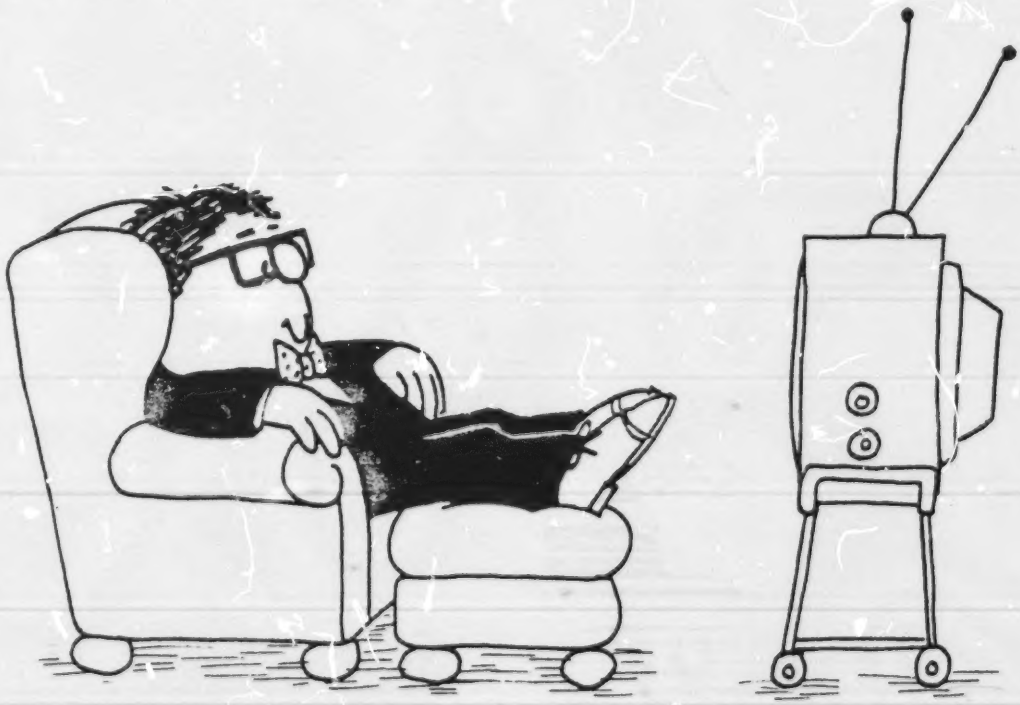
Materials: 6 Slides
30-Second Audio Cut-8 seconds for local announcer

How to Use

The TV spot is designed to sell the entire energy education program. There are eight seconds at the end for your individual "tag". Bring the slides and audio cut to your local TV station. Give them the copy for the tag and they will complete the audio. Show them the TV storyboard (EXAMPLE G) and they can just follow its directions when putting the spot together. Ask them to superimpose your name and phone number over the bottom of the last slide.

When to Run

I would recommend running your spot in shows like "The Today Show", "Good Morning America", local news, "The Tonight Show" and shows that run in prime-time access or from 6:30-7:00 PM. Prime time (7:00-10:00 PM) will generally eat up your budget too quickly. When you run a TV schedule, try to achieve some frequency as well as reach. Don't spend your budget on a few spots in prime time when for the same money, you can buy many more spots throughout the day.



Brochure

13

BROCHURE

Materials: Artwork for Side 1: 8½ x 11" unfolded; 3 5/8 x 8½" folded
Artwork for Side 2: 8½ x 11" unfolded; 3 5/8 x 8½" folded

How to Use

This brochure gives you the opportunity to go into more detail about all the courses you offer. It's the most comprehensive of all the ad materials. The brochure cover is camera ready. Inside, the course modules are set up with illustrations and titles. Have your printer add a headline-"(school name) presents"- plus your copy about each course where indicated. Use the course modules you desire and have your printer position them to fill up the space. The printer will also have to set up your course schedule and add logos where indicated.

A plain white paper stock is suggested for the brochure. It should be printed in two colors: black and red. Tell your printer that the red should be PMS-485 and have him follow the instructions on the artwork as to what is black and what is red. SEE EXAMPLES H. & I.

When to Use

The brochure provides a ready source of information when questions arise and it lets you zero in on prospective prospects. For example, you might mail it to people who have participated in past adult education courses, use local Chamber of Commerce mailing list, or use an area wide mailing.

Statement Stuffer

16

STATEMENT STUFFER

Materials. Artwork for Side 1: 3½ x 6½"
Artwork for Side 2: 14 module illustrations (see newspaper)

How to Use

The statement stuffer is designed to promote a single course. Side one is camera ready artwork; side two requires some composition. Have your printer insert the desired module illustration and add your copy where indicated. Use white paper stock and print in red ink (PMS-485). SEE EXAMPLE J.

When to Use

A statement stuffer can be an effective and economical way to promote your courses. Ask your local banks and utility company if your stuffer can go out with their monthly statements as a public service. Grocery stores may also agree to stuff your piece in their grocery bags.

POSTER/BUTTON/BUMPER STICKER

Materials: Artwork for 11 x 14" poster
Artwork for 2½" diameter button
Artwork for bumper sticker (7 1/2" x 3 3/4")

How To Use

Poster. Poster advertising reaches people while they are out and about. This poster is designed to be flexible in promoting a number of single courses. Ask your printer to blow up the artwork to 140% of its original size. Type must also be set for your school name and phone number. Have the poster printed on heavy white paper or tag board with red ink--PMS-485. Order enough posters printed up to cover all your courses. Then use a black magic marker to fill in the pertinent information for each course in the provided blanks. EXAMPLE K.

Button. Buttons serve to promote general program awareness. Contact a specialty advertising representative to order them. The artwork for the buttons is camera ready. Specify white letters on a red background--PMS-485.

Bumper Sticker. Bumper stickers also serve to promote general program awareness. Contact a specialty advertising representative to order them. The artwork for the bumper stickers is camera ready. Specify white letters on a red background -PMS-485. EXAMPLE L.

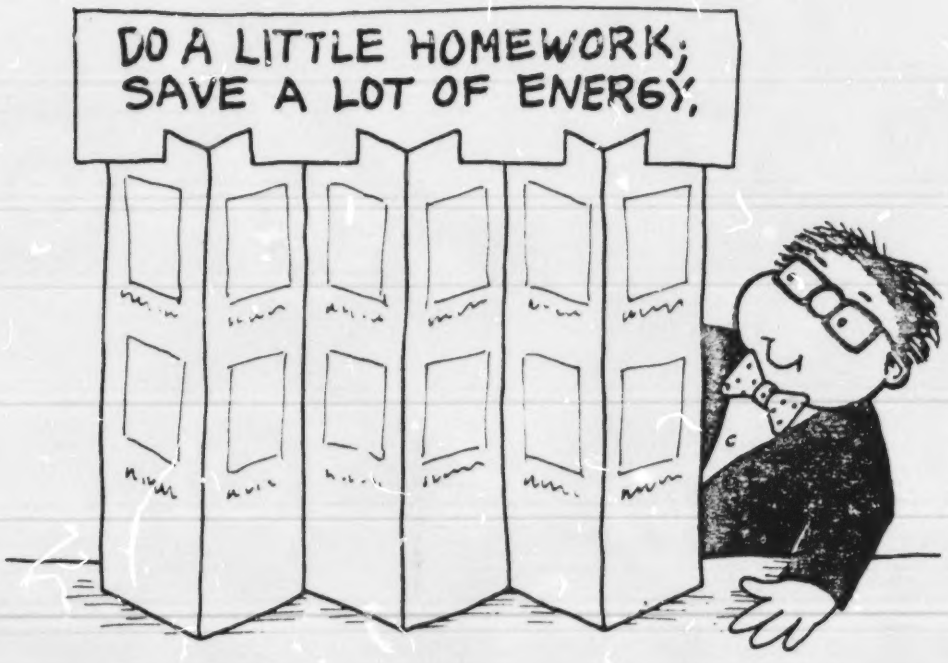
EXHIBIT

Materials: Exhibit Blueprint

How to Use

An exhibit for special events adds another dimension to your promotion efforts. By following the instructions on page 22 (SAMPLE M), you can construct an inexpensive, yet sturdy and attractive display. The basic exhibit material is heavy poster board - available at any art supply store. You can add your message to the poster board in one of several different ways - paint, stencil, vinyl paste-on letters, presstype (again, check your local art store).

Keep your display simple and uncluttered. Use a dominant, easy-to-read headline and then support it. Use interesting art/graphic elements, e.g. blowups of module illustrations or photographs. This exhibit is to be set up on a table with your literature in front of it.



SPECIAL EVENTS

Special events are an excellent way to promote your energy education program and in some cases you can offer energy education classes as a part of the special event.

It is suggested that you use the opportunity that presents itself in existing special events to promote your energy education program. Set up a display and distribute information on energy conservation during:

American Education Week (November)
American Vocational Education Week (February)
County Fair
Open Houses
Parade of Homes
other special events in your community

In addition you can create or help to create a special event related to energy conservation. Many communities have proclaimed an energy week, a sun day or other energy event to get the citizens involved in energy conservation efforts. With your energy education you should be an active participant in any such event.

OTHER PROMOTION CONCERNS

In developing your energy education program, one of the best ways of promotion is word-of-mouth. It is important that your initial program get off to a good start so that students help sell the program to their friends and acquaintances.

TEACHER

As with all education programs, the teacher is the key to a quality presentation. The teacher should have a technical background in the subject to be presented, an understanding of the adult student, and an interest in helping others through energy education.

CURRICULUM AND VISUAL MATERIALS

A curriculum guide with slides and transparencies has been developed for each of the consumer energy education topics listed under course titles. It is important that the instructor become familiar with these materials prior to the class presentation. Teacher workshops are offered periodically to help teachers get acquainted with the materials.

HANDOUTS, MODELS, ETC.

It is suggested that local handouts, fact sheets and other materials be developed. In addition, sample materials and models should be secured from building materials suppliers. Wherever possible, involve students in applying the knowledge presented (ie: caulking)

TIMING

Just as in promoting other products, your energy education program will be seasonal. Try to time your classes to meet homeowner interests. Insulation, caulking, and weatherstripping will sell best in the fall. Wood heating safety will go well in early winter. Roof ice dams or ventilation will be of interest in late winter when the problem has appeared, and window treatments could be a spring class.

APPENDIX B

TARGET AUDIENCE IDENTIFICATION

The entire superinsulation curriculum covers thirteen, sometimes diverse, sections. Figure B-1 indicates which section of the superinsulation curriculum are most appropriate to specific target audiences. A banker, for example, is interested in Life-Cycle Costing for superinsulated homes, but not in learning how to size roof overhangs for summer shading. Builders and insulation contractors are interested in vapor barrier controls, but probably have little interest in Life-Cycle Costing.

B-1

FIGURE B - 1

TARGET AUDIENCE IDENTIFICATION

SECTION	Primary Audience (Instructors)	Students and Apprentices	Home Builders	Insulation Contractors	Mortgage Granters	Realtors and Appraisers	Building Material Suppliers
I. Low Energy Housing	X	X	X	-	X	X	X
II. Introduction to Superinsulated Construction							
A. Robinson Rules-of-Thumb	X	X	X	X	X	X	X
B. Critical Elements	X	X	X	X	X	X	X
C. Superinsulated Retrofit	X	X	X	X	X	X	X
D. Conclusion	X	X	X	X	X	X	X
E. Bibliography	X	-	-	-	-	-	-
II. Infiltration							
A. Vapor Barriers	X	X	X	X	-	-	X
B. Foam Sealants	X	X	X	X	-	-	X
C. Air-to-Air Heat Exchanger	X	X	X	X	-	-	X
D. Bibliography	X	X	-	-	-	-	-
IV. Walls							
A. Single Wall Strategies: New Construction	X	X	X	X	X	X	X
B. Double Wall Strategies: New Construction	X	X	X	X	X	X	X
C. Single Wall Strategies: Retrofit Const.	X	X	X	X	X	X	X
D. Double Wall Strategies: Retrofit Const.	X	X	X	X	X	X	X
E. Bibliography	X	X	X	X	-	-	-
V. Attic							
A. New Construction	X	X	X	X	X	X	X
B. Retrofit	X	X	X	X	X	X	X
C. Roof Overhang Sizing and Shading	X	X	X	-	-	-	-
D. Bibliography	X	-	-	-	-	-	-
VI. Foundations							
A. Foundation Walls: New Construction	X	X	X	X	X	X	X
B. Foundation Walls: Cement Slabs	X	X	X	X	X	X	X
C. Foundation Walls: Retrofit Construction	X	X	X	X	X	X	X
D. Foundation Walls: Retrofit	X	X	X	X	X	X	X
E. Bibliography	X	X	X	-	-	-	-

SECTION	Primary Audience (Instructors)	Students and Apprentices	Home Builders	Insulation Contractors	Mortgage Granters	Realtors and Appraisers	Building Material Suppliers
VII. Windows							
A. Window Criteria	X	X	X	X	-	X	X
B. Bibliography	X	-	-	-	-	X	X
C. Window Treatments	X	X	X	X	-	X	X
VIII. Entrances							
A. Doors	X	X	X	X	X	X	X
B. Air Locks	X	X	X	X	X	X	X
C. Bibliography	X	-	-	-	-	-	-
IX. Indoor Air Pollution							
A. Classes of Pollutants	X	-	X	X	X	X	X
B. Impact of Energy Efficient/Solar Design on. . . .	X	-	-	-	-	-	-
C. Health effects of Elevated Indoor Generated Pollutants	X	-	-	-	-	-	-
D. Control Strategies	X	-	-	-	-	-	-
E. Conclusion	X	-	-	-	-	-	-
F. References	X	-	X	X	X	X	X
X. Air-to-Air Heat Exchangers							
A. Air-to-Air Heat Exchanger Description	X	X	X	-	-	X	X
B. Air-to-Air Heat Exchanger Features	X	X	X	-	-	X	X
C. Air-to-Air Heat Exchanger Installation	X	X	X	-	-	X	X
D. Air-to-Air Heat Exchanger Economics	X	X	X	-	-	X	X
E. Bibliography	X	X	X	-	-	X	X
XI. Heating and Cooling Systems							
A. Heating and Cooling System Sizing	X	X	X	-	-	X	X
B. Heating System Selection	X	X	X	-	-	X	X
C. Electric Heating System	X	X	X	-	-	X	X
D. Natural Gas Heating Systems	X	X	X	-	-	X	X
E. Wood Heat	X	X	X	-	-	X	X
F. Cooling System Selection	X	X	X	-	-	X	X
G. Bibliography	X	-	-	-	-	-	-

SECTION	Primary Audience (Instructors)	Students and Apprentices	Home Builders	Insulation Contractors	Mortgage Grantors	Realtors and Appraisers	Building Material Suppliers
XII. Superinsulation Economics							
A. Simplified Economic Analysis	X	X	X	X	X	X	X
B. Detailed Economic Analysis	X	X	X	X	X	X	X
C. Life-Cycle Costing Advantages	X	X	X	X	X	X	X
D. Pay-back	X	X	X	X	X	X	X
E. Return on Investment	X	-	-	-	X	X	-
F. Life-Cycle Costing Methodology	X	-	-	-	X	-	-
G. Years-to-Positive Cash Flow	X	-	-	-	X	-	-
H. Can Retire Loan	X	-	-	-	X	X	-
I. Value of Installed KW Capacity not needed	X	-	-	-	X	X	-
J. Cost of Energy not Consumed	X	-	X	X	X	X	X
K. Superinsulation's Annual Effectiveness	X	X	X	X	X	X	X
L. Bibliography	X	-	-	-	X	-	-
XIII. Marketing Superinsulation							
A. Marketing Philosophy	X	X	X	X	X	X	X
B. Superinsulation Benefits	X	X	X	X	X	X	X
C. Bibliography	X	-	-	-	-	-	-
XIV. Consumerism							
A. Consumer Questions and Answers	X	X	X	X	X	X	X
B. Bibliography	X	-	-	-	-	-	-

APPENDIX C.

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
1. What is Superinsulation?	
2. Superinsulation Means: -Save Energy	
3. Superinsulation Means: -Save Energy -Save Dollars	
4. Superinsulation Means: -Save Energy -Save Dollars -Create Profits	
5. Superinsulation Means: -Flexibility	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
11. Bar chart-showing heat loss reductions from various house components as the house becomes super insulated. The first bar represents a 2 x 4 house (R-22 attic, R-11 wall etc.) annually requires 900 gal. of fuel oil. The second 2 x 8 house (R-60 attic, R-30 wall, etc.) annually requires 140 gallons. And the third double wall house (R-8 attic, R-50 walls, insulated shutters , etc.) requires 1/2 gallon of oil annually, for heating.	
12. Heat Load Reductions (shows typical heat loss reductions for a house built to Minnesota State Building Code, compared to Superinsulated schedule.)	
13. Simplest Things First (Philosophy of Superinsulated Designers and Builders)	

C-2

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
6. Superinsulation Means: -Paying Attention to Detail -Using Common Sense	
7. Superinsulation Means: -1/4 air change per hour -Continuous vapor barrier	
8. Superinsulation Means: -Hourly Air Change rate of 1/4 or less -Effective Air Infiltration Barriers -Air-To-Air Heat Exchangers	
9. Superinsulation Means: -Wall R-values of 30 or more -Ceiling R-values of 50 or more -Basement wall R-values of 20 or more -Windows triple glazed or more	
10. Superinsulation Means: -10 to 14% glass area to floor area -70% of glass area facing south -30% of glass area facing non-south	

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
14. ROBINSON RULES-OF-THUMB	
15. Relative R-Values for Polystyrene (part of Robinson Rules-of-Thumb)	
16. For Below Grade R-Values	
17. For Minimum Annual Cost	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
18. NorthStar House: built in 1981, by Swanco (Brooklyn Park, MN) (South View)	
19 NorthStar House (North View)	
20. Hand House, built in 1981 by Hand Construction (Anoka, MN) (North View)	
21. Kirkwood House, built in 1979 by Kirkwood Voc. Tech (Kirkwood, IA) (South View)	
22. Solar Saltbox, built in 1979 by Linda and Micael Scott of (Northfield, MN)	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
23. Saskatchewan Conservation House, built in 1977 by Saskatchewan Research Council (South View)	
24. Saskatchewan Conservation House (North View)	
25. Ivanhoe House, built in 1977 by David A. Robinson (Northfield, MN) (South View) Note early superinsulated homes incorporated active and passive solar components which were discovered as not energy or cost effective.	
26. Infiltration	
27. Vapor Barrier Installation (Detailed explanation of vapor barrier installation to be followed from left to right)	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
28. Areas of Infiltration	
29. Infiltration Controls -Vapor Barriers -Form Sealants -Air-to-Air Heat Exchangers	
30. Vapor Barrier	
31. Vapor Barrier, under cement slab basement floor	
32. Vapor Barrier, overlap on framing space	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
33. Vapor Barrier, overlap between ceiling and wall	
34. Vapor Barrier application around ceiling fixtures	
35. Vapor Barrier application around wall outlet	
36. Vapor Barrier application around rim joists (Canadian wall)	
37. General Vapor Barrier showing how crosshatching can be used to avoid penetrations caused by utility runs	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
38. Foam Sealants	
39. Electrical Utility Infiltration path before foam application	
40. Electrical Utility Infiltration path after foam application	
41. Sealing Utility run Infiltration path	
42. Foam Sealant placed around window frame	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
46. Walls	
47. Insulated sheathing on house exterior provides needed thermal break for superinsulated walls built on a single stick wall	
48. 2 x 6 Wall Framing	
49. 2 x 8 Wall Framing	
50. Insulation in headers between floors	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
51. Alaskandinavian Wall (wall section)	
52. Alaskandinavian Wall (emphasis on vapor barrier)	
53. Utility Run in Alaskandinavian wall	
54. Double 2 x 4 wall framing (wall section)	
55. Double Wall Framing (top plate view)	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
56. Insulating Double Wall	
57. Double wall with wood foundation	
58. Above Grade wall section, double wall	
59. Exterior Retrofit of Existing house	
60. Attic	

C-12

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
61. Attic wall section	
62. Cathedral Ceiling (wall section)	
63. Foundation	
64. Below Grade wall (wall section)	
65. Insulation Board being applied to exterior (notice cantilever plate)	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
66. Foundation Insulation (exterior application)	
67. To control Basement Heat Loss: - - - -	
68. Foil backed Insulation Board precision cut and sealed in *place in joist area to form* warm side vapor barrier.	
69. Insulation below basement slab	
70. Protective Cover over above-grade insulation board	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
71. Below Grade wall section (inside wall exploded view)	
72. Windows	
73. South windows -6-10% glass area to floor area	
74. Other windows -0%-4% glass area to floor area	
75. North Star House (notice awnings for summer shading of south windows)	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
76. North Star awnings	
77. Overhang for south windows	
78. Deluxe interior window treatments	
79. Windows in foot-thick wall (North Star House)	
80. Framing and Vapor Barrier detail for double wall (St. Cloud Mayor, Sam Houston)	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
81. Entrances	
82. Insulated Doors	
83. Air-Lock entries	
84. Air-lock entries (Interior/Exterior)	
85. Indoor Air Pollution	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
86. Moisture Build-up (Humidity)	
87. Bath and Kitchen Odors	
88. Smoking (Smoker or in ash tray)	
89. Particulates	
90. Sulfur & Nitrous Oxides from gas cooking	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
91. Formaldehyde	
92. Radon	
93. Heat Exchanger	
94. Air-to-Air Heat Exchanger	
95. Air-to-Air Heat Exchanger built from plans purchased from University of Saskatchewan	

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
96. Q-DOT type of air-to-air heat exchanger	
97. Z-Duct type of air-to-air heat exchanger	
98. Enercon type of air-to-air heat exchanger	
99. Van EE air-to-air heat exchanger	
100. Controls on air-to-air heat exchanger	

C-20

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
101. Air-to-Air Heat Exchanger connected to furnace duct system	
102. Superinsulation Economics	
103. Tax Credits	
104. Picture of Scott twins in a twin sink (illustrates importance of internal gains, inside the superinsulated home. Humans produce 100 watts of heat)	
105. Ideas for Superinsulated Model Homes	

SUPER INSULATION CURRICULUM SLIDES

SLIDE DESCRIPTION:	INSTRUCTOR NOTES:
106. Ideas for Superinsulation Model Homes	
107. Ideas for Superinsulation Model Homes	